POWER

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The Point of View

IN ONE of the best sellers of years ago Jerome K. Jerome told of a trip up the Thames in a rowboat.

Numerous things conspired to mar the voyagers' complete enjoyment, among them the saucy little power-propelled craft which were always tooting them out of the way and threatening to run them down.

For the return trip, however, they were glad to accept the invitation of a friendly owner of one of these nuisances to come aboard and take their boat in tow.

It was great to skim along at such speed without the toilsome back-breaking effort that had marked their progress upstream and made them so willing to ride back. The only annoyance was those pestilential little rowboats that persisted in getting in their way.

Somebody said that a dissenter was likely to become a conformist when he got to own a horse and buggy. Modern history is not devoid of examples of those who were aggressively against the established order while they were in the grind, but became hard-boiled advocates of the status quo when they got to share its advantages.

Standpatism means a surcease of progress, the relative retrogression that goes inevitably with smug satisfaction with things as they are.

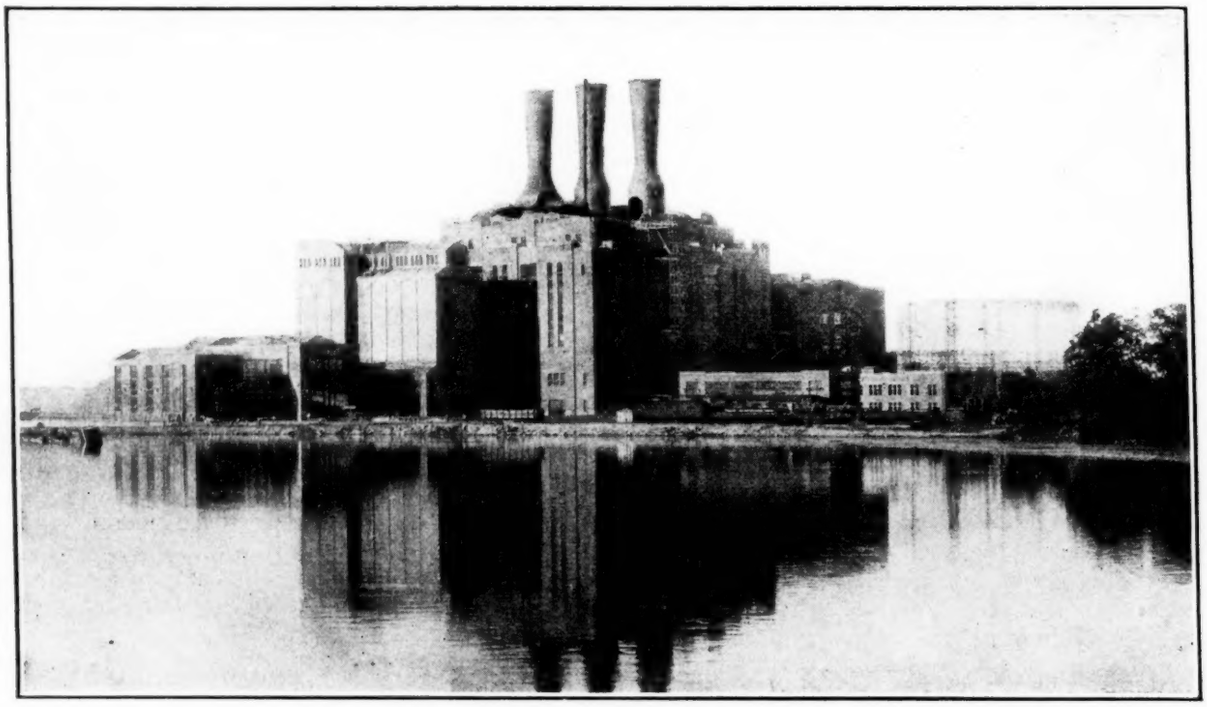
Iconoclasm, the ruthless tearing down of established conditions simply because they are agreeable and profitable to somebody else, without the substitution of a more inclusive system of benefits, is senseless.

A struggle for the substitution of a system that will transfer the beneficences from one class to another is simply the yanking of one man off the horse that the other may ride, and means perpetual strife for the saddle.

True progress lies in the direction of hitching the horse to something that both can ride in.

Perhaps this would be easier of attainment if each party to the controversy could bring himself to see the other's point of view.

F. R. Low



Eighteen Months' Experience at
Trenton Channel Station

By ALEX DOW
President, The Detroit Edison Company

THE following was prepared by Mr. Dow to keep his promise that experience with the novel or unusual features of this, the latest, power plant of The Detroit Edison Company would be given full publicity after a sufficient time had elapsed to justify conclusions.—Editor.

THE Trenton Channel plant has been in operation for two years. During the first six months operation was interfered with by construction work and by the adjustments that always have to be made after a plant is running. During the last eighteen months two of the first three 50,000-kw. turbine-generator units (50,000 kw., 62,500 kva., 1,200 r.p.m.) have been continuously available. The other unit was continuously available until it was taken out of commission two months ago, after the fourth unit went into commission, to permit replacement of shaft packing on the high-pressure end of the cylinder and the first wheel, both of which were damaged eighteen months ago, but not so severely as to prevent operation. The following notes of experience can, therefore, be accepted as based upon eighteen months' practical service of three units, and an output of 1,002,000,000 kw.-hr. in that period.

The plant is designed for six identical 50,000-kw. turbine-generators. The turbine room was completed during 1926 to accommodate all six; the boiler room has been completed for the necessary number of boilers, the fourth turbine-generator (50,000 kw., 75,000 kva., 1,200 r.p.m.) is in commission as previously stated; the fifth is being erected, and the sixth is under order.

The difference in kva. rating for the three later generators is not due to any radical change, but to improvements such as cross-twisted conductors, nonmagnetic end shields and better ventilation, all of which will be applicable to the earlier generators. Two of the turbines are running with governors and thrust bearings which are not of the designed type. The parts required to change these are on hand, but it has not been possible heretofore to spare the machines from regular duty long enough to make the substitution. Each turbine is of the single-cylinder type. The steam pressure at the throttle is 390 lb. with a total temperature approximating 700 deg. F. In the boiler house the additional boilers and furnaces are the same as the original boilers and furnaces, using pulverized fuel in air-cooled furnace chambers, and having hearth screens which are in effect small separate boilers having their own feed-water supply and water level and discharging their steam into the main steam drum.

The precalculated thermal efficiency was 16,000 B.t.u. per kw.-hr. of net output at a generator voltage of 12,000 to 13,000. The generator output is literally net, because all the station uses are supplied from inde-

pendent auxiliary generators, while all the output of the main generators is stepped up to 120,000 volts and delivered to outgoing transmission lines. For the eighteen months' period the actual efficiency has been better than the calculated efficiency. This result has been obtained with an annual load factor of 58 per cent, which means that the station took its share of the work and was not in any way made a base-load plant.

The operating cost, including all maintenance costs, has been similarly less than the calculated figure—which means that it has been possible to operate and maintain the plant with the estimated number of employees working the estimated number of hours, and without unforeseen expense for maintenance material.

In the design (as was frankly said at the time) there was no attempt either to make a record in terms of thermal units or of man-hours. What was sought was a smoothly operating plant with low total costs. Inasmuch as the plant is not yet finished, I am not offering any final figure of cost per kilowatt or kilowatt-hour.

Our theory of operation does not allow us to make a base-load plant of Trenton Channel. We will be tempted to have a base-load plant at Delray if we ever get around to rebuild that plant. But we observe that the base-load plant of today becomes the stand-by plant of five or ten years hence, and we shall deal with the base-load problem as and when we come to it, without making it the excuse for costly design. What I call attention to is that Trenton Channel takes its share of the ups and downs of our system, and that our decision not to build a so-called base-load plant has thus far been justified.

Steam Pressure

The single-cylinder turbine makes good use of steam up to about 400 lb. pressure. If we were to select a higher pressure, we would use two cylinders, either tandem or cross-compound. Four hundred pounds was chosen because it appeared to represent the upper limit for a single-cylinder turbine and because it also represented the point at which the standard method of making riveted boiler drums with planed joints and double butt straps and turned and fitted heads could be applied to the well-known Delray type of boiler, with drums of 48-in. diameter. The plate is two inches thick. At higher pressures smaller drums would have been necessary, which would have required the use of a smaller number of 3½-in. tubes (that is to say, a smaller boiler) unless the number of drums per boiler were multiplied; or else forged drums would have had to be used. I do not think there is any principle of design implied by this observation that 400 lb. gage pressure marks the line above which the manufacturing costs of turbine and boiler must step up quite sharply. I think the coincidence is accidental.

Direct Current Auxiliary System

We have had more comment by visitors concerning the direct-current auxiliary system than any other feature. These 4,000-kw. twin direct-current generators, driven by cross-compound geared turbines, do look expensive. Any visiting designer who had a pencil handy would figure that our auxiliary system was costing too much. But visitors who were responsible for day-to-day operation of their own plants were likely to say that they would be glad to exchange their own auxiliary arrangements for the exceedingly simple control and switch equipment which we showed them; for the 250-volt copper busbars carried by Alberene stone cleats and insulated with cotton duck stitched on by a sail maker; for the absence of oil-filled switches and alternating-current safety devices.

Those direct-current generators are run up to speed and put on to the auxiliary system in the most casual way by an engine-room attendant. When one of them is to be taken off, all that is done is to shut the throttle. A reverse-current relay trips the circuit-breaker as soon as there are a few amperes of reversed flow of current. The range of speed of the direct-current auxiliary motors is anything desired up to the 1 to 4 ratio of the motors feeding the pulverized-coal burners, and the motors are efficient at low speeds. With the exception of one generator commutator which misbehaved (possibly in order to prove the rule) there has been literally no commutator trouble. The starting and speed control gear is placed wherever convenient and is absurdly simple, and any electrical part of the 250-volt direct-current auxiliary system can be handled without gloves.

Our friends who have adopted the method that is at the moment considered to be the most efficient—namely, the use of a house alternator on an extension of the main turbine shaft—say that the efficiency is all right but the convenience is something else again. They say that they do not, in practice, synchronize these house generators with one another because the phase angles of the corresponding main generators may not coincide. Therefore, they use separate busbars and throw-over switches. They say likewise that the saving in using alternating-current conductors at 2,300 volts is largely offset by the cost of switch gear and relays.

Pulverized Fuel

Operation of the pulverized-coal plant is successful and satisfactory and concurs with all the assumptions made in advance. If we had to build a similar plant today we would, I believe, repeat the choice of a separate preparation house. If the decision were to be made a year hence, I think that we might choose unit pulverizers.

The air-cooled furnaces had minor troubles due to local overheating. These have been minimized by better arrangement of the air ducts. If we were designing a new plant today we would probably use water cooling in the furnace walls—although possibly we would not use the entirely water-cooled furnace with these type W Stirling "Delray" boilers, rated at 2,909 hp. each. The separated hearth screens work well, and experience with them justifies the opinion that it is best (at least with very large boilers) to have any furnace water-cooling system separately fed and not to link it into the water circulation of the main boiler.

The Cottrell precipitators in their earlier form were decidedly temperamental but the later form promises to be reliable. They intercept a fine grit which proves, upon analysis, to carry a fairly constant amount of carbon. The claim of automatically perfect combustion of pulverized fuel is not justified, and we did not calculate that it would be. The advantages which we really expected, of a wider choice of fuel, great flexibility in operation, and the cutting of stand-by losses, have been realized. The every-day output of steam from each boiler has been greater than expected. We take 25,000 kw. regularly out of each boiler. Our allowances for possible trouble with refractories and for

possible difficulties with certain classes of fuel were too conservative. The immediate result of this is that for the present there will be installed only fourteen boilers instead of eighteen. We can see, however, that the possibility of installing more boilers may be helpful in case changes in fuel markets or fuel freight rates make it profitable to use a lower grade of coal. Also, with the dust and noise of fuel preparation confined to a separate house, it is easy to make a boiler room look as it should. Even the necessary repairs are made with less mess than in our best stoker plants.

Disposition of the Grit and Cinders

At Trenton Channel there is no difficulty in disposing of the fine grit recovered from the precipitators and from the dust passages of the boilers. It is sluiced into a lagoon which is being filled, and there are more lagoons and marsh lands to be filled. But at the city plants where stokers are used we are not required to dispose of the cinders at our own cost. There is a market for them. A carload of cinders—say 50 cu.yd.—sells on the side track for $35 during the months when building construction is active, and in Detroit it is active during all the year. There is also a well developed industry making and marketing a cinder concrete brick, which asks for more cinders than we have for sale. Someone will have to discover a commercial use for the fine grit from the Cottrell precipitators before we can install pulverized fuel at, say, Delray where there is no lagoon to fill. I have no doubt that such a use will be discovered, but in the meantime we are neither willing to pay freight charges for shipping the grit from Delray to a marsh needing filling, nor are we willing to distribute it over surrounding territory by way of our chimneys.

To complete these comments on pulverized fuel, I am going to answer one question which has been asked by our visitors, and avoid answering another such question. The first question is whether we, after having acquired experience during two years' operation of a large plant with pulverized fuel, are satisfied that we did well in choosing pulverized fuel instead of the best of the stokers that were available? The answer is yes, and there is no qualification whatsoever to that answer. The decision was well and wisely made. In saying this, we are taking account of recent improvements in stoker practice as well as of our experience with pulverized fuel. The other question is whether we will choose stokers or pulverized fuel for our next plant or our next addition to an existing plant elsewhere. We will cross that bridge when we come to it. In the meantime we do not answer.

Some Other Experiences

The single-pass condensers, of course, introduce no new condenser problems, but the low level of the Detroit River and some specialization in the plant design have led to their operating during week-ends with a siphon of approximately thirty feet. That is to say, the level of the circulating water in the top of the condenser was thirty feet above the tail water in the overflow, and this condition required no change in method. The operation of the motor-driven extraction pumps and feed pumps on one shaft was not entirely satisfactory to begin with; but the difficulty, after much study and elimination of unforeseen air leaks, etc., resolved into a problem of piping rather than any problem of pump design. In the new units, instead of putting the extraction pump on the same shaft as the feed pump, we are driving it electrically from a small alternating-current generator carried on the feed-pump motor shaft. That permits the extraction pump to be located directly below the condenser, and yet to keep in step with the feed pump. It introduces some new problems, which are not problems in pumps but in the design of an alternating-current generator and motor for variable frequency.

Trenton Channel is one of the few large plants using steel tube economizers and not using deaërators. Makeup water is distilled as usual, and the surge tanks are protected as well as is conveniently possible from access of air to the stored water. The condensers are evidently removing air to a sufficient degree to safeguard the economizers, but our experience indicates that this detail of operation needs careful supervision. The rotating dry-vacuum pumps with vertical cylinders, motor driven, are an improvement on the horizontal type, in that they occupy less space. Our persistent use of rotating pumps is another item in which our design has been criticized as costly, but we have not yet seen anything equally good. Of course we are watching the impovements in steam-jet devices for removing non-condensable vapors.

In making the joints on the 400-lb. steam pipe lines we adhered to our practice of using a Van Stone joint with a thin fabricated gasket. These joints are all right at the higher pressure and their use is being continued.

The Trenton Channel plant thus far has furnished no surprises to its designers, and has done a little better than the estimates—as might be expected of new machinery well handled. What it will continue to do after it is doubled in capacity and its full load operating and maintenance regime is established, is a question that cannot be answered now, but will be answered willingly when the time comes.

Ten Tons of Water (about 320 cu.ft.) falling 100 ft. develops the energy equivalent to that which can be produced through the burning of one pound of coal. That is, ten tons, or 20,000 lb., falling 100 ft., will develop 2,000,000 ft.-lb. Dividing this by 778 gives 2,570 B.t.u. of energy. Assuming a hydraulic turbine efficiency of 92 per cent, which is a fair average for a modern hydraulic turbine, the energy actually developed from this water is about 2,370 B.t.u. This corresponds to the energy made available by the combustion of coal having a heating value of 13,000 B.t.u. per lb. with an over-all plant thermal efficiency of approximately 18 per cent, which is perhaps fairly representative of good central-station practice although not equal to the best, which approaches 25 per cent.

The Amount of Compound necessary in cylinder oil depends upon the moisture present, but rarerly exceeds 10 per cent. The normal amount is about 5 per cent, and where the amount of water is small, it can be reduced to 3 or 4 per cent. Oil having a higher percentage of compound seems to have no advantage whatever over oil that contains only 7 or 8 per cent. It is expensive and there is a greater possibility of sludges and deposits being formed in the lubricators.

How Thick Should Pipe Covering Be?

Greater Thicknesses Give Slightly Greater Heat Savings, but There Is a Limit Beyond Which the Extra Saving Will Not Warrant the Additional Investment

By C. C. HERMANN

IT IS well established fact that the cost of covering steam pipes, feed-water pipes, boiler steam drums, receivers and separators is readily regained through the saving of fuel. It is not, however, very well understood just how thick the covering should be in order to accomplish these desirable results.

We might argue, for instance, that a sheet of 85 per cent magnesia an eighth of an inch thick will pay for itself in a certain time through savings of heat loss and be on the right side. If an eighth inch is good, will not an inch be better? Will two inches be better than one? Obviously, there must be some limit to the thickness that will pay.

Selecting the Proper Thickness

The proper thickness of a covering varies with two factors, namely, the temperature difference between the steam within the pipe and the air around the outside of the pipe, and the diameter of the pipe. I know of no table or data that give this information in a more compact and understandable way than the following:

TABLE SHOWING SUITABLE THICKNESS OF 85 PER CENT MAGNESIA FOR VARIOUS CONDITIONS*

	Zones of Temperature				
	100 to 267 Deg. F.	268 to 338 Deg. F.	339 to 388 Deg. F.	389 to 600 Deg. F.	601 to 800° Deg. F.
Pipes under 2-in.	Standard	Standard	Standard	Standard	Double standard
Pipes 2-in. to 4-in. inc.	Standard	Standard	Standard	Double standard	3-in.
Pipes over 4-in.	Standard	1½-in.	Double standard	3-in.	3½-in.

* Reproduced by courtesy of Ehret Magnesia Manufacturing Co.

Standard thickness increases by steps with increasing pipe size and is as follows:

Nominal pipe size, in., inclusive	½ to 1½	2 to 3½	4 to 6	7 to 10	12 and larger
Thickness, in.	1 in.	1 1/32 in.	1¼ in.	1½ in.	1¾ in.

Double standard is merely two standard-thick layers.

It is noticed that with the lower temperatures the thickness of the covering is given as standard or practically uniform thickness, while with the higher temperatures the thickness of the covering is greater for the larger pipes. This may seem surprising in view of the fact that the loss per square foot from bare pipes is greater on small diameters than on large diameters and also that the efficiency of the covering is less on the smaller pipes than on the larger ones. One might easily jump to the conclusion that the insulation should be thicker on the smaller pipes. However, commercially it is found more practical to increase the thickness for larger pipes in order to make the sections easy to handle and eliminate loss through flimsiness. Moreover, the actual saving in B.t.u. per unit of list price increases with the diameter of the pipe, but decreases with the thickness of the insulation.

The increase in efficiency by increasing the thickness of covering on different size pipes is very small. For example, a given covering of 85 per cent magnesia two inches thick has an efficiency of 91½ per cent for a 2-in. pipe. The efficiency of this same thickness applied to a 5-in. pipe is 93½ per cent (two points higher), and for a 10-in. pipe it is 94½ per cent (three points higher than for a 2-in. pipe).

Working with a 3-in. thickness of 85 per cent magnesia, the efficiency increases from 93½ per cent for a 2-in. pipe to 95 per cent for a 5-in. pipe and 96 per cent for a 10-in. pipe. It is to be noted that these savings are based on a temperature difference of 500 deg. F. between the steam and the air.

It is well to bear in mind that, for the sake of uniformity engineers often specify the same thickness on all pipes. This practice is justifiable where the amount of smaller pipe is inconsiderable in proportion to that of larger size. The thickness chosen depends upon the local conditions, efficiency desired, condensation allowable in the steam mains and the effect of such condensation on equipment.

Covering Should Be of High Efficiency

In the first place it is desirable and advisable to obtain a covering of rather high efficiency if the investment is to be made at all. The percentage return on the investment, however, decreases as the efficiency increases, and it would not be advisable to expend too much effort and capital in order to increase the efficiency one or two per cent. In other words, there is a middle ground where the engineer can rest without danger of much criticism.

To reduce the problem of thickness to a practical solution, it is well to divide the saving of the covering in B.t.u. per lineal foot per hour per degree temperature difference by the list price of the covering in dollars per lineal foot in order to obtain the B.t.u. saving per lineal foot per hour per degree. F. temperature difference per one dollar list.

For example, a certain 2-in. covering, having an efficiency of 91½ per cent, costing $1 per lineal foot (list), provides a saving of 2.83 B.t.u. per lineal foot per hour per degree temperature difference. This gives a factor of 2.83, which is the B.t.u. saving per $1 list.

Compare this with a 3-in. covering of the same pipe size, which costs $1.65 per lineal foot and produces a saving of 2.89 B.t.u., or 1.75 B.t.u. per $1 list. The efficiency of the 3-in. covering is 93½ per cent, or two points higher than that of the 2-in. covering, yet its saving is 1.08 B.t.u. lower per $1 list price. In short

we are paying $0.65 for 0.03 B.t.u. saving per lineal foot per hour per degree temperature difference.

For a 10-in. pipe the saving per $1 list price of covering 85 per cent magnesia two inches thick is 5.15 B.t.u. as against 3.44 B.t.u. per $1 list for the same covering three inches thick. With a list price of $2.40 per lineal foot for 2-in. covering and $3.65 per lineal foot for 3-in. covering we realize a saving of only 0.20 B.t.u. per lineal foot per hour per degree temperature difference for an added expenditure of $1.25. The saving of additional heat by the increase in thickness costs at the rate of $5.95 per B.t.u. per lineal foot per hour per degree temperature difference in the latter case, and in the case of the 2-in. pipe the cost of additional saving is at the rate of $21.66 per B.t.u. per lineal foot per degree temperature difference per hour.

These examples show that as the diameter of the pipe increases the rate of increased cost per B.t.u. saving decreases. It is not advisable, therefore, to place too much dependence on the comparative efficiency of pipe covering and expect this to provide an economical installation. The increased saving may not be sufficient to pay the interest on the additional investment required to obtain the increased thickness.

Where the Money Goes

*In the Refrigerating Plant**

By ROY H. SMITH

IN AN ice plant the prime object of the engineer is to make a good product at the lowest cost possible. He may feel that his primary duties are to keep the wheels turning over, but he will find that the keeping of records of the operation and the essential items of cost will be time well spent. An efficient compressor is of little value if its efficiency is offset by a careless use of supplies or a loose labor schedule. These are all important factors that must be co-ordinated by the engineer if he is to have a low production cost.

Major Operating Costs

To begin with, a definite system should be followed out daily in the keeping of the major items of cost, such as labor, power and water. Records of supplies may be obtained at regular intervals from the office. The cost of supplies along with the operating and labor costs are the essential factors over which the engineer has control. They do not represent the actual cost of the ice, as there are fixed charges, such as taxes, insurance, rents, depreciation, administration expenses, etc., but someone else will take care of these.

A book should be kept with headings something like this: Ice produced today, ice produced to date, put in storage, taken out of storage, ice on hand, daily payroll, cost of labor per ton of ice, number of men, kilowatt-hours per ton of ice, water per ton of ice and such other items as may apply to the particular case involved. Most of these items are on the daily log sheet any way, and it is an easy matter to enter them in this book. With the records entered in this way, the whole month's operation is available at a glance without thumbing through a pile of sheets.

It would be well to base all costs on per ton of ice manufactured, as this is the unit most generally used. By entering the "per ton" costs and the consumptions daily, it will not be long before the engineer will know how the labor should be running for a certain production schedule, how many kilowatt-hours, and the quantity of water he ought to be using to make a ton of ice. He will notice when the figures are running high and will immediately try to find the cause. At the end of the month he will have totals that can be averaged easily, and with the records running over a period of years he will have a basis of comparison that will be invaluable. It is a good idea to copy the power and water bills in this book on the pages for the corresponding months. A column should be provided for the keeping of the sales in this record also, as they will be found useful in anticipating the demand for a certain period and in laying out the production schedules.

In some plants it may be desirable to go into more detail on the labor by splitting up the daily payroll into the different classes of labor such as tank room, storage room, engine room, platform, etc. This is good as it may be possible to change the labor from one class to another to advantage, and showing up lost motion at the time it occurs, will permit immediate correction. Comparisons should be made in man-hours per ton, which will remain fairly constant even under changing conditions.

Everything that is done should be compared to a standard. The standard may be based on past operations that are known to be good under the particular conditions existing, or may be a certain specified standard set up by someone qualified to do so. In either event any change from standard results will indicate that something is wrong either with the equipment, organization or operation, and it is for the engineer to determine just what factor is not functioning as it should.

Backing Up Claims with Records

To sum up the whole idea, do not grope around in the dark, but by keeping records and making comparisons, know that you are right or know that you are wrong, and after you have done your utmost, do not be afraid to ask for help. In a constructive way appeal to your employer and admit that results in the plant are not what they should be and make any recommendation that you think will secure the desired results. The employer would appreciate your ability to observe poor results and your co-operative spirit in reporting them to him, but it is impossible to do this unless it is known whether costs are high or low.

As an illustration, assume that the manager has a good job open and that there are two candidates for it.

*Abstract of paper presented at the seventeenth annual convention of the National Association of Practical Refrigerating Engineers, Kansas City, Mo.

One is a good mechanic who knows an ice plant from the top of an ammonia drum to the cake of ice sliding down the chute, but does not know and does not seem to care what it costs to do the work. The other candidate is admittedly not so good an engineer from the mechanical point of view, but is conscientious, careful and closely in touch with every operation of the plant, trying to get that cake of ice out cheaper than it was ever done before. Which man is more valuable to the owner? The first applicant, who is a good mechanic, may make a repair job himself and save $500 in the operation. The other man probably would have to call for a little help to do this same job, but is likely to make 75,000 tons of ice for the year at 20 cents a ton cheaper than the first man and save the owner $15,000. It is apparent that the latter man is the most desirable for the job and this is not said with any idea of detracting from the value of a good mechanical refrigerating engineer. The comparison simply shows that costs must be considered. Of course it is the happy combination of the two that makes the best engineer. "Results at the least cost" are the key words in this day of keen competition, and men are judged by their ability to perform on this basis.

Every ice plant has certain log sheets which, too often, are looked upon as a sort of bugbear that goes along with the daily operation. To be of any value, the entries must be made regularly and correctly. The log should show the details that must be known every day in the particular plant for which it has been designed. Entries most commonly made are suction and discharge pressures, temperatures of water on and off the condenser, brine, storage room, liquid ammonia, and atmospheric temperatures, ice pulled and on hand, and many other items. Readings should be recorded every hour, and this means readings, not guesses. A log so kept keeps the engineer alert and covering his plant. His work becomes more interesting because he knows more about it, and above all the log is extremely valuable to the employer and the engineer, as it keeps them accurately and intelligently in touch with the plant operation hourly and daily.

The Manager's Job

The foregoing is the engineer's part of the story. Now the plant owner or executive in direct charge of the engineer should realize the importance to himself of a good engineer in whom he has placed the entire responsibility of the amount of production, what it costs, and the care of the equipment in the plant. Give him the utmost encouragement and the incentive to want to lower the costs and to keep his plant in good condition. Let him feel that it is his plant and his responsibility to make that plant pay. To do this, co-operation with the engineer is necessary. Get him to feel that he is working with you and not for you. Lean a little toward him in giving him what he wants to run the plant rather than dictate and specify every little item with which he is supposed to get the results you expect. At least give him a voice in what is required, for there is a psychological response in everyone to make something work that he says will work. On the other hand, if something is forced on the engineer that he does not much favor, he will not be enthusiastic about seeing that it does work. Put it up to the engineer in terms of results and expect him to get them, but do not curtail him too closely to your own ideas in doing so.

Another factor that is of the greatest importance to both owner and engineer in obtaining the common objective, which in this case is the best product at the least cost, is nothing more nor less than absolute honesty on the part of each. The plant owner should be open and above board in all his dealings with the engineer, such as to working conditions, compensation, what he expects of him, his promises to him, etc. Give him no reason to become suspicious that you are trying to outmaneuver him. Settle your mutual problems openly and fairly, be careful to promise only those things that you expect to fulfill—because false promises are sure to destroy confidence—and be diplomatic both with your dealings with the employer and with the men under you who, after all, are of importance.

Adoption of these policies will gain the confidence of the engineer, his respect and his willing obedience to your wishes. He will be eager to do his best and will do ten times as much, and do it better, than a man who serves you just because that is what he is supposed to do in order to get his pay envelope.

Looking Facts in the Face

From this honesty policy the chief engineer is not exempt. He has as many opportunities to be frank and square as the owner. He should do his best at all times, and if the time comes when his best is not good enough to master the conditions, he should be honest enough with himself and his employer to admit it. He should tell all he knows about the plant, whether good or bad, and be as conscientious in the handling and using of the equipment and the money as if it were his own. This may seem to be a departure from the subject of operating records and costs, but in the writer's opinion the most important single item in reducing operating costs is the personnel, and the most vital factor in the personnel is an honest engineer in the right frame of mind working with, not for, an honest plant owner or executive.

Add to the engineer and the plant owner, the supply man, and we have the three classes of men whose honesty has a bearing on the costs. Before recommending certain equipment or supplies for specific service, the supply man should honestly believe that they are the proper things to use. In making the sale he should never allow his own selfishness to overrule his honest judgment. A clear conscience when facing the engineer or the buyer is worth much more than a few dollars of commission. Sell the engineer the best equipment for the job, do not overload him with something he does not need, and honestly try to help him. Doing these things will insure royal treatment in any man's engine room or office and pays in the long run for an engineer soon realizes the degree of reliability of a salesman's word.

One of *Power's* Readers is anxious to purchase or gain access to the second edition (1909) of a German publication on the purification of boiler feed water. This was published by A. Sydel, of Berlin, under the title, "Die Reinigung des Kesselspeisewassers." E. Herdepriem was the author of the original work, and the revision was made by J. Bracht and Dr. C. Hansdorff. The publisher advises that this edition is out of print. If anyone possessing a copy will communicate with the editor of *Power*, the information will be most welcome.

Further Details of Hudson Avenue
80,000-Kilowatt Turbine Unit

Provision for Thermal Expansion of Casings and Rotors—Rapid Governor Action Secured Through Double Relay Control—Shaft Seals and Thrust Bearing

THE Westinghouse turbine recently installed in the Hudson Avenue Station of the Brooklyn Edison Company is the largest turbine unit now in operation, and many details of its construction are of interest to engineers concerned with turbine design and operation. On page 815 of the issue of *Power* for Nov. 30, 1926, is the forerunner of the present article. The two together simply cover the more conspicuous features of the unit.

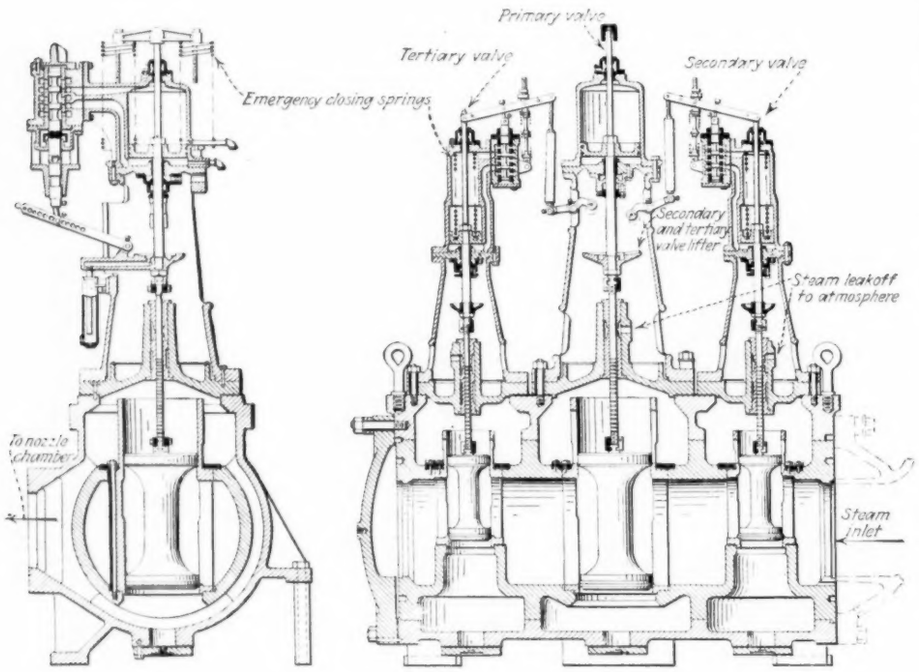


Fig. 1—The steam chest houses three governor valves

The main valves are one-piece forged steel poppet valves guided in steel cases with ports designed to give as nearly as possible a straight-line relation between valve lift and steam flow. In long valve-stem bushings, generous leak-offs are used in the valve bonnets to prevent undue steam leakage and at the same time avoid unnecessary stem friction, so as to reduce the load on the governor.

In considering the somewhat elaborate arrangements for expansion, it must be remembered that the turbine cylinder is at the temperature of the steam within it, whereas the pedestals and other parts are at approximately room temperature, and that the consequent differential expansions are of considerable magnitude.

The high-pressure cylinder is supported on brackets located on the sides of the bearing pedestals. The cylinder support lugs are made integral with the main castings, with their bottom surfaces near the center line to eliminate any change in vertical alignment due to change of temperature in these parts. The pedestal at the exhaust end, which carries one turbine bearing and one generator bearing, is bolted rigidly to the foundation. The longitudinal position of the cylinder is fixed by two long struts secured to either side of the pedestal, which restrain the cylinder from end movement, but permit free sidewise expansion. The weight of the cylinder is carried by the lugs resting on the supporting brackets. A vertical key held between two lugs on the forward end of the bearing pedestal holds the cylinder in alignment against side motion, but permits vertical and longitudinal expansion relative to the pedestal.

The turbine bearing at the governor end of the unit rests in a pedestal mounted on a separate soleplate bolted to the foundation, and the pedestal is free to slide endwise between guides which prevent side motion and thus preserve the alignment.

The cylinder and governor-end bearing are maintained in transverse alignment by a vertical key, and struts fix the axial relation of the cylinder and pedestal, and since this carries the thrust bearing, these struts preserve the required relative positions of moving and stationary blades.

The cylinder base and cover are each made in two parts, bolted together on a vertical joint. The horizontal joints were first finished, and the upper and lower halves of the high- and low-pressure sections, respectively, were bolted together. The vertical flanges were then finished, with a groove of rectangular section in each. A dowel ring was machined to fit the grooves in the high- and low-pressure portions, the halves of this ring were carefully fitted, and the vertical joint was bolted together. The horizontal joint was then unbolted, and the upper and lower parts of the cylinder were thereafter considered each as one piece.

The low-pressure turbine is supported on four corner feet that are made a part of the main cylinder castings. The guiding of the low-pressure cylinder to permit free expansion is carefully worked out. The cylinder is anchored transversely and longitudinally at the

coupling end. Transverse movement at the thrust end is prevented by a key which permits free longitudinal movement. The corner supporting feet are free to expand in any direction, as they rest on lubricated supports.

The receiver pipe from the high-pressure turbine is connected directly to an extension collar that is, in turn, bolted directly to the upper half of the blade ring.

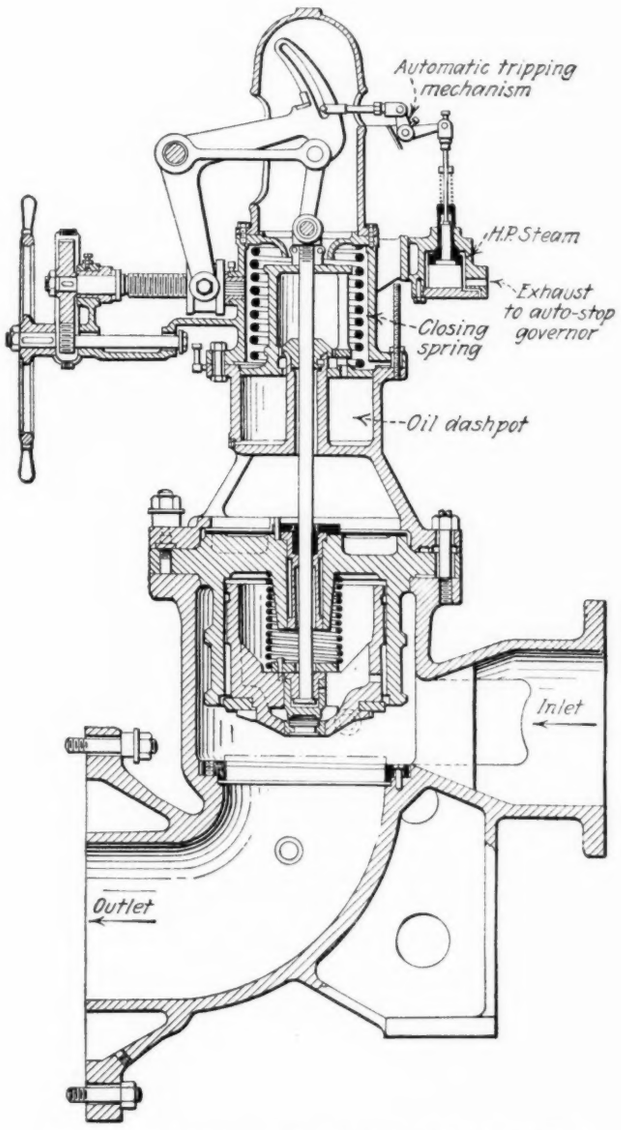


Fig. 2—The 22-in. main throttle valve has offset connections to reduce the pressure drop

The operating mechanism is of standard construction save for the back gear between the handwheel shaft and the screw, to reduce the effort required. When the trip gear operates, the latch at the top of the valve opens, allowing the valve to be closed by the main spring. The dashpot prevents too rapid closing.

To permit the free expansion of the blade ring, a circular copper seal plate is used.

The governing system consists of a standard flyball governor operating the main governing valves through a double-relay hydraulic system. The main governor, of standard design, controls a 4-in. power piston by means of a 1¼-in. diameter relay. With these proportions the governor follows the speed with no appreciable lag. The governor oil pressure is set at about 65 lb. gage.

In the steam chests and main governing valves the 4-in. primary operating piston already mentioned is connected through a linkage to the main 3-in. relay that controls the high-pressure oil supply to the 14-in. primary valve operating cylinder. With the mechanism as described, the governor is free to resume the equilibrium position with very little lag, and as the

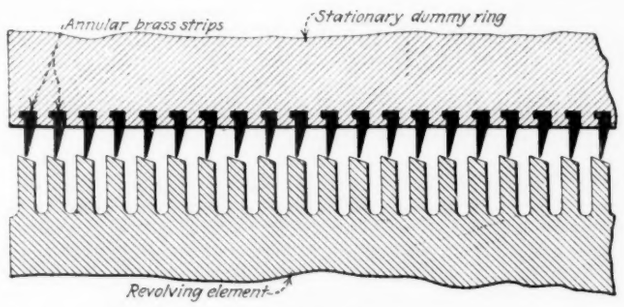


Fig. 3—The dummies, of which there are two sets, are of the radial contact type

The lands of the spindle dummy rings are turned conical with the larger diameter toward the coupling end of the shaft. The dummy strips are initially fitted to give a radial clearance less than normal, and the spindle is displaced toward the coupling end. The dummies are then "ground" after starting the turbine by adjusting the thrust bearing until the strips touch the lands. This "grinding" gives a minimum running tip clearance.

hydraulic and frictional resistances are small, the main power relay is controlled with promptness and precision because of the power action of the 4-in. operating cylinder. The double-relay mechanism is the most suitable arrangement for the control of large steam-turbine valve gears in which rapid action is required to prevent the tripping of the overspeed stop when the maximum

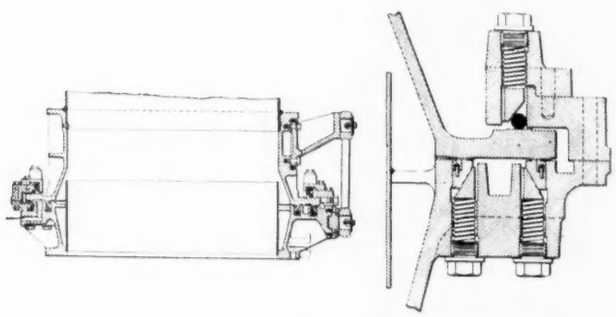


Fig. 4—Expansion joint for 70-in. receiver pipe

Free expansion of this pipe, with steam and air tightness presented a serious problem. This joint, adjacent to the low-pressure unit, consists of two elements held at a fixed distance apart by external links. Segmental packing rings form a seal chamber which is supplied with condensate from a head tank. A third packing ring prevents steaming of the atmospheric drain when the steam pressure is high.

load is released in one step. During the last year many governor tests of exceptional interest were made under service conditions, in which loads as high as 70,000 kw. were released in one step from a single unit to determine the regulating characteristics of the governors.

There is no oil dashpot in the governor mechanism on this turbine, as good stability can be secured without this device. The dashpot invariably slows down the action of the governor to an undesirable extent.

The secondary and tertiary valves in the steam chest are fitted with independent relays and operating cylin-

ders that are controlled by pick-up mechanisms actuated from the power side of the main primary valve operating system.

In addition to the main governor there is the usual automatic stop governor at the thrust end of each turbine spindle. Tripping of either stop governor will close the main throttle.

The steam chest and throttle valve assemblies are anchored rigidly to the power-plant structure adjacent

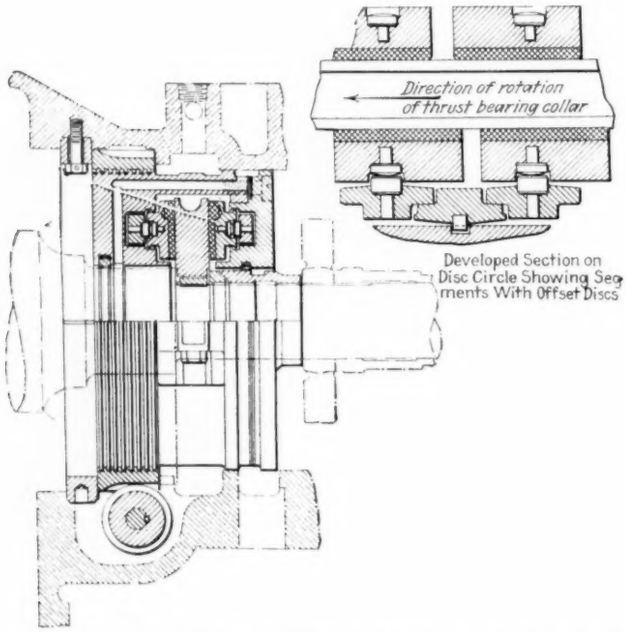


Fig. 5—The Kingsbury thrust bearings show several improvements

The babbitted steel segments are supported by leveling blocks to distribute the load uniformly more effectively than the oder type of spherical seat ring. The friction is less and the segments need not be of precisely the same thickness. The cage is split horizontally to facilitate removal of segments, and a vent prevents the formation of gas pockets that would impair the lubrication. A calibrated micrometer adjustment of the shaft is provided at the rate of 0.005 in. per turn of the adjusting worm. The maximum unit thrust under extreme overload does not exceed 250 lb. per sq.in. of bearing surface.

to the primary valve in the steam chest. Flexible supports at other points provide anchorage without creating undue stresses from the expansion of the valve parts themselves. By this type of anchorage the stresses caused by the expansion of the main steam

TABLE I—PRESSURE AND TEMPERATURE DISTRIBUTION FOR BEST POINT LOAD OF 65,000 KW. WHEN STEAM IS EXTRACTED FOR HEATING FEED WATER IN FOUR STAGES TO 361 DEG. F.

	High-Pressure Inlet	Impulse Chamber First Bleeder Point	Between Blade Rings in High-Pressure Turbine Second Bleeder Point	High-Pressure Turbine Exhaust Third Bleeder Point	Low-Pressure Turbine Fourth Bleeder Point	Low-Pressure Turbine Exhaust
Pressure, lb. per sq. in. absolute	375	169	82.5	27.1	5.45	0.492
Temperature, deg. F.	699	537	405	244.5	166	79

line from the boiler room are not transmitted to the turbine structure.

The flexible pipes from the steam chest to the high-pressure turbine nozzle chamber inlets were furnished by the turbine builder, and have sufficient flexibility to permit expansion, both of the pipes and of the turbine parts, without undue stresses at any point. In this way the general engineer of the power plant is not harassed by debates between his engineers and the turbine manufacturer regarding steam-pipe stresses imposed upon the turbine structure. This arrangement places the matter of steam-pipe stress on the turbine structure entirely in the hands of the turbine manufacturer.

In order to reduce the expansion forces, the pipes between the steam chest and the nozzle chamber inlets are reduced in size to give approximately 250 ft. per sec. steam velocity. The steam is accelerated to this velocity by properly formed nozzles at the outlet of the steam chest. The flexible pipes are led through long-radius bends to the nozzzle chamber inlets. Before entering the nozzle chambers, the steam velocity is reduced to 125 ft. per sec. through small angle diffusers, so that the total loss in pressure by this arrangement is

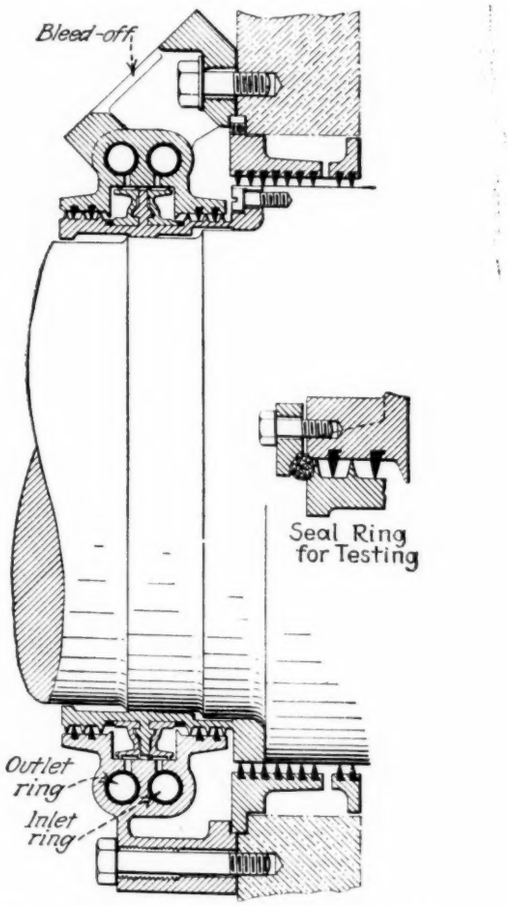


Fig. 6—The water-sealed spindle glands

All glands are of this type, but only the high-pressure turbine glands have the steam leak-off to the low-pressure bleeder point. The sectional manganese bronze runner is secured to a stainless steel shaft sleeve, which provides a continuous barrier to leakage. Water enters and leaves through two series of radial holes, and flows outward, opposing any tendency of air to be carried inward by eddy currents. This design minimizes the quantity of water used and the supply pressure.

small, whereas considerable added flexibility and reduction of volume is secured.

A study of the wide range of ratings possible with little change in efficiency indicates that many factors must be considered in securing low power costs. Closer co-operation between the plant designer and the turbine builder should lead to still greater reductions in the cost of power generation than have yet been obtained, through the proper study of the economics of large turbine applications.

Applying Ground Detectors to Control Circuits

By RALPH B. GREENWOOD

THE common type of lamp ground detector contains the possibilities of causing false operation of control apparatus. Suggestions are made as to how these troubles may be prevented.

TWO types of ground indicators, or detectors, are used to disclose a ground that may develop on control circuits. The most common arrangement consists of two 25-watt tungsten lamps permanently connected in series across the control bus from which the various control circuits are supplied. This connection is shown in Fig. 1, and it will be noted that the connection between the lamps is permanently grounded at *A*. The voltage rating of each lamp must closely correspond to that of the control bus. This ground indicator functions as follows:

Action of the Ground Lamps

Assume that a ground of zero resistance develops at *B*, Fig. 1. Under this condition lamp 1 is short-circuited and extinguished because of the two grounds at *A* and *B*, and lamp 2 burns at full brilliancy. The current flows as shown by the arrows and is limited to 25 watts divided by 129 volts equals 0.194 ampere.

Normally—that is, with all control circuits free of grounds—each lamp burns at half brilliancy, since the lamps are in series, and the voltage drop across each is one-half of the control-bus voltage. If the resistance of the ground at *B* is increased, lamp 1 gradually increases and lamp 2 decreases in brilliancy, until both present the same appearance. Using 15-watt tungsten

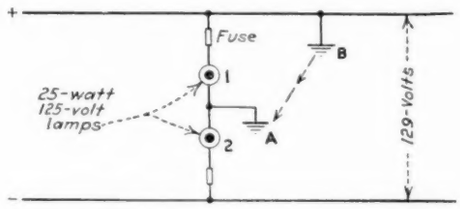


Fig. 1—Diagram of connections for lamp ground detector

or carbon lamps, the minimum difference in voltage between them that is visible to the eye is about 5 volts, taking 65 volts as the base. With 50-watt tungsten lamps this minimum voltage is about 8 volts; that is, if 65 volts is normally applied to each 50-watt tungsten lamp, their voltages must be about 61 and 69 to be noticed by the average observer.

If each lamp is considered as a voltmeter, the effect of a ground is more evident, as is also the reason why the ground lamps burn at different brilliancies when a ground of other than zero resistance develops. Care must be taken to use lamps of identical ratings, otherwise a false ground indication will result. As an example, in one plant where ground lamps are connected to each exciter, eight large generators and two exciters were disconnected from the excitation bus before it was found that the false ground indication appeared because a burned-out lamp had been replaced by one of incorrect rating.

The lamp connected to the grounded conductor becomes dim or even dark, depending on the resistance of the fault. Thus, in Fig. 1 lamp 1 becomes dark, because it is connected between the positive conductor

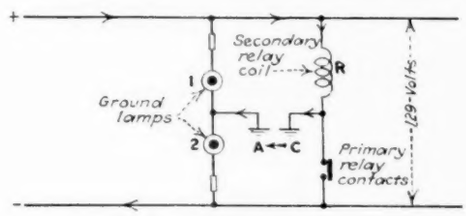


Fig. 2—Shows how relay coil can be energized through ground-detector lamp

that was grounded and the permanent ground. It is helpful to mark the polarity of each lamp near its receptacle, since it is then evident at a glance whether the positive or negative conductor is grounded.

Indications Obtained on the Lamps

If two 10-watt tungsten lamps are used on a 130-volt circuit, a ground of 15,000 ohms will result in a perceptible indication. By replacing the 10-watt lamps with tungsten lamps rated at 50 watts, the maximum ground resistance that will give an indication is approximately 4,500 ohms. From this it is apparent that the lamp type of ground indicator is a sensitive device if small lamps are used. The relative brightness of the lamp is an indication of the resistance of the ground. The simplicity, cheapness and dependability of this detector have brought it into widespread use.

There are two objections to the use of lamps as ground detectors. One is that, since the permanent resistance to ground from either conductor is rather low, a high voltage that may be developed between the control bus and ground, may cause enough current to flow through the lamps to destroy them completely. High voltages induced in excitation systems have been known to jump a considerable gap to a neighboring control circuit, with resultant destruction of ground lamps, sockets and connected wiring. It is probable that immunity from this hazard can be obtained by using 2,000-volt 1-ampere fuses to protect the ground lamps instead of the usual 250-volt fuses.

Another and important objection to lamp ground indicators is that should a ground develop at a certain point, sufficient current will flow through a 25-watt lamp to energize some types of secondary relays and cause the opening of one or more circuit breakers. Referring to Fig. 2, a ground is shown at *C*. Current

flows according to the arrows, from *C* to *A*, thence through lamp 2, with the result that relay coil *R* is energized although the primary relay contacts are open.

Relay Type of Ground Detector

In some stations a relay type of ground detector is used to eliminate the troubles that have been found to result where ground lamps have been employed. This device is shown diagrammatically in Fig. 3. In this figure *R* is a differentially wound relay. The midpoint of its winding is permanently grounded. A 2,000-ohm resistor is connected between each bus conductor and the relay. While the control bus is free of grounds, the magnetizing effect of the current through each of the relay coils is equal, but opposite in effect, since the coils are differentially connected. Should a ground develop, as shown at *B*, Fig. 3, coil *M* will be weakened owing to being shunted by the two grounds *A* and *B*. At the same time coil *N* will be strengthened, since more current is flowing through it than through *M*. The coils still oppose each other, but since the magnetizing effect of *N* is greater than that of *M*, owing to the difference in their respective currents, armature *K* is attracted to the relay core, and indicating lamps *S* and *T* are lighted. By adding a relay, a signal bell may be sounded upon the occurrence of a ground of sufficiently low resistance. The differential relay tested, indicated all grounds having a resistance of 3,000 ohms or less. This relay is known as the E-117 Western Electric telegraph type.

The advantage of the relay-type ground detector is that, because of the series resistance used, it is protected against high voltages, sufficient current will not flow when a ground occurs to operate secondary relays, and a signal can readily be provided to give instant warning of the occurrence of a ground.

One reason why grounds should be located and cleared without delay is apparent from Fig. 4. In this case it is assumed that ground *B* first developed. This

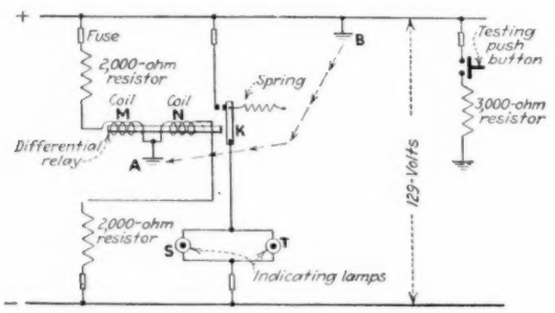


Fig. 3—Connections for relay-type ground detector

would, of course, be immediately shown by either type of ground detector. Ground *C* is assumed to have occurred before ground *B* could be cleared. The result is that current flows through the circuit-breaker trip coil exactly as though the control switch was closed. This condition is not unusual, and switches may be either opened or closed, or opened and closed repeatedly.

Ground detectors of either type should be tested daily to avoid their failure to operate. By connecting a suitable resistor to ground through a push-button, as shown in Fig. 3, the relay will be operated if all connections are intact. Ground lamps may be tested in the same manner, and if conditions are normal during the test, one lamp will become brighter than the others.

Grounds occur on circuit under so many different conditions and combinations of conditions that their effect may be almost anything imaginable. For this reason, when a ground develops on a control circuit it should be removed at the earliest opportunity, since if there are any weak spots in the insulation on the oppo-

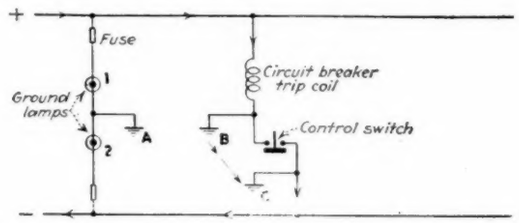


Fig. 4—Shows how grounds on a control circuit may cause false operation of circuit breakers

site side of the system, they are subjected to double potential and may fail in a short time. If the only result of the two grounds were the blowing of a fuse or opening a circuit breaker to disconnect the faulty line, the danger of a ground on the system might not be so imminent, but, as previously shown, switches in other circuits may be caused to open or close or other serious effects may be produced.

Diesel Engines Burning Producer Tar

A German concern, the L. Schwartzkopff Machine Co., of Berlin, has succeeded in running a Diesel engine on lignite tar as fuel. This tar is derived from the heating gas used for annealing purposes. The producers equipped with exchangeable retorts utilize industrial briquets. Part of the gas is taken from the retorts by suction and freed from the tar. This tar has the following properties: Black green color; melting point, 104 to 122 deg. F.; coking residue, approximately 2 per cent; minimum heating value 16,380 to 16,920 B.t.u. per lb.

The Diesel engine used is of the air-injection type and has an output of 440 b.hp. As long as the tar can be supplied to the cylinders in the liquid state, the engine operates without ignition oil. All piping up to the fuel pump is therefore heated by the cooling water of the engine. Before starting, the tar in the tanks and piping is solid, and a second fuel is therefore required for starting and warming up the engine. While this is being done, a small starting reservoir of tar is also warmed up to the melting point by a hot-water circulation. The same fuel pump is used for the initial fuel and the tar and by suitable connections either of the fuels may be handled.

The employment of one and the same fuel pump for two different fuels at first gave rise to minor difficulties, because the starting oil must be of such a nature that when mixed with tar no precipitate is formed. Investigations made with a number of oils at 80 deg. C. showed that they all produced certain pitch-like precipitates when mixed with tar. With oils derived from lignite they were a minimum and softest, while with mineral gas oils they were considerable and hard throughout. So far two kinds of lignite oils have proved most satisfactory.—*Engineering Progress.*

Power Plant of the
Federal Reserve Bank of New York

Boilers Arranged for Either Coal or Oil—Simple Corliss Engines Employed—Peaks and Night Load Taken by Edison Service

By HENRY C. MEYER, Jr.*

ALTHOUGH this plant has now been in operation for two years, this is the first description to be released by the bank management.—Editor.

THE Federal Reserve Bank Building, which was completed in the fall of 1924, was a structure especially designed to meet the needs of the New York Federal Reserve Bank; hence it contains a number of features out of the ordinary. It rises sixteen stories above ground and has five basements, the floor of the lowest being about 80 ft. below Nassau Street. The volume of the building is about 13,000,000 cu.ft.

The manner in which the building is used requires the concentration of a considerable number of workers, so much so that artificial ventilation was necessary, and this, coupled with the very large number of machines operated by small motors and used for commercial purposes, meant that the power load would be greater than in most buildings.

A study of the power-plant requirements showed that a maximum load of about 1,200 kw. was to be expected. The only space available for the plant was in the eastern end of the building, which was somewhat restricted laterally on account of the shape of the property, although there was plenty of room vertically for such equipment as the building might require. It was decided that the best arrangement include two 600-kw. generating units driven by slow-speed Corliss engines. The simple Corliss engine with a steam pressure of about 140 lb. was considered the most economical engine to use, especially at partial loads. It should not be forgotten that in office-building service with a considerable number of electrically operated elevators the average load is considerably below the maximum on account of the wide variation in the elevator load.

It was decided to make arrangements for a connection with the New York Edison Co. for a maximum demand of 600 kw. which could be used at any time in the event of a breakdown of one of the generating units, or to take any slight excess in load over the capacity of the generators. The cost of this service is a fixed amount, and as a definite quantity of electricity would be supplied for this sum, it was believed that the cost would be absorbed in running on the Edison service nights and Sundays; at such times shutting down the generating plant and thus saving in the cost of fuel and saving in the engine-room labor.

The engine room contains two 600-kw. simple Corliss units

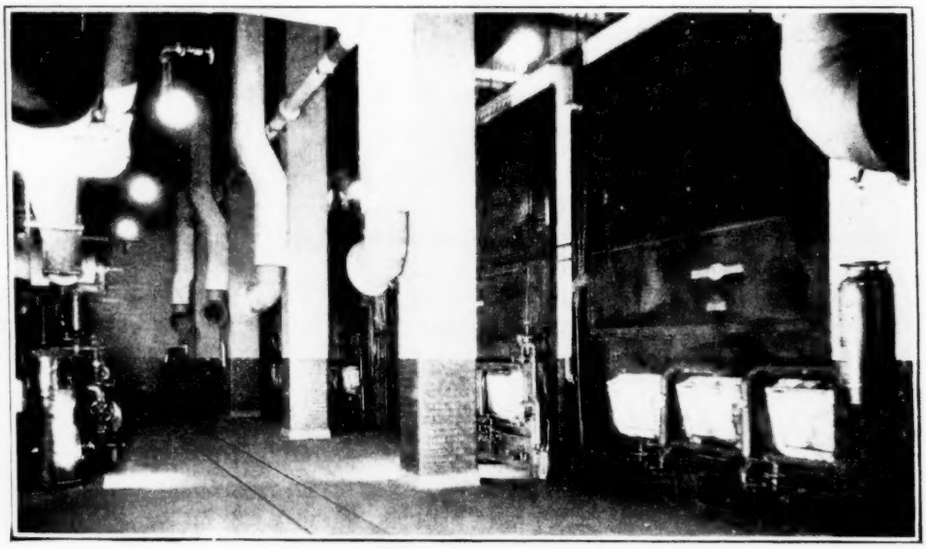
Provision was made for the delivery of coal through a truck entrance and lobby entirely separated from the rest of the building. Coal is delivered into a hopper in the floor of the driveway, from which it is chuted to a crusher; thence it goes to a conveying belt running across the building, which in turn delivers to either one of two longitudinal conveyors, discharging directly through automatic trippers into the coal bunker. The coal crusher can be bypassed in case hard coal is used.

On account of the difficulty experienced by large buildings in getting coal during coal strikes and because of the fluctuating prices of coal and fuel oil, which at

*Consulting engineer for the mechanical and electrical equipment.

times would make it more advantageous to use oil instead of coal, the bank decided to install fuel-oil equipment for use when conditions made the use of fuel oil desirable, and for this purpose two rectangular tanks, each holding 22,000 gal., were installed in the lowest basement, each fed through a filling pipe in the sidewalk. Steam-actuated burners are used with the usual auxiliary equipment. In addition to that a hot-water heater supplied by steam and equipped with a small motor-driven circulating pump is provided for circulating warm water through coils at the bottom of each tank in order that it can be heated, should it for any reason become sufficiently cool to prevent the oil pumps from sucking the oil out through the top of the tank.

The boiler plant consists of five 3,500-sq.ft. boilers of the cross-drum type, set with a 9 ft. 6 in. high furnace in order that fuel oil or soft coal could be burned to advantage. The fronts are so constructed that mechanical stokers for burning soft coal may be installed at any time should it be desirable to do so. It was expected when the plans were prepared that the boilers would be operated with No. 2 or possibly No. 3 buckwheat coal. The bank, however, made a favorable contract for fuel oil, and the boilers are now being operated with that form of fuel.



The boilers are equipped for either fuel oil or coal

It was felt that four of the five boilers would meet the maximum demand of the building with a fair grade of No. 3 buckwheat coal, leaving one boiler out of service for repairs or cleaning. Inasmuch as four boilers might not always be available, and a poor grade of coal was to be expected at any time, steam-driven air-blast units are provided for increasing the draft should any one of these contingencies arise. It is difficult to get much more than the normal rated capacity out of the boilers with natural draft with the small sizes of anthracite. Water-tube boilers are expensive in these days, and further boiler capacity to meet the contingency mentioned would be far more expensive in first cost than the mechanical draft equipment.

Boiler meters are provided, recording the temperature of the flue gases and the quantity of the combustion. Steam-flow meters record the total steam generated, the steam to the engines, to the kitchens and live steam used for heating.

The electric generating plant consists of two 600-kw. two-wire direct-current generators, each directly connected to a simple Corliss engine, operating at 140 lb. The unbalance in the 120-240 three-wire lighting system is taken care of by small balancer sets. The steam main is of the ring type with branches to the engines and the auxiliary equipment that can be fed from either end. Receiver separators of ample volume are provided for each engine.

The switchboard controlling the electric generators and balancers is of the remote-control type. The control buttons, solenoid-operated generator circuit-breakers, and the automatic starters for the balancer sets and their control buttons are located on a switchboard in the engine room. The light and power distributing feeders for the building also concentrate at this switchboard. The switches or circuit-breakers for these feeders are connected together by buses in groups of convenient capacities, and provision is made so that any group can be supplied either by the generating plant or by Edison service.

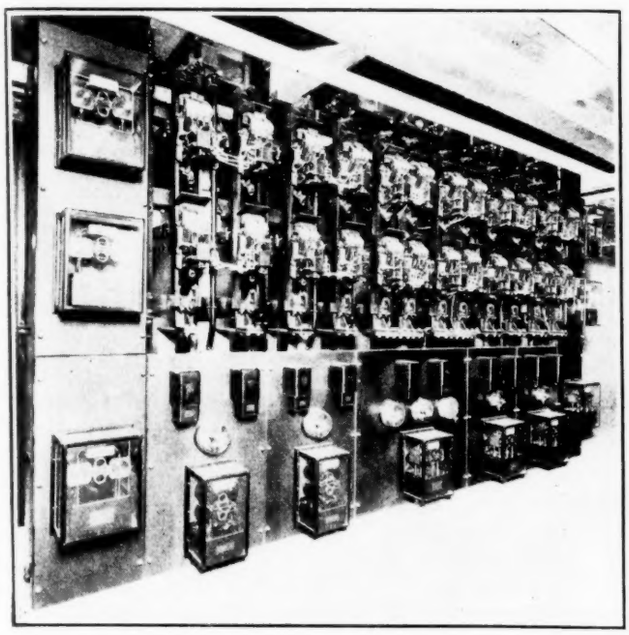
For the purpose of throwing over the feeders from one service to the other, a bus connection is installed from each feeder group to a double-throw solenoid operated switch located on a switchboard in the basement below. One side of these switches is connected to a bus supplied from the generators. These solenoid switches are controlled by buttons on the engine-room switchboard. By the operation of a single button any subdivision of the load may be transferred from one service to the other practically instantaneously. Signal lights are provided at each control button to indicate that the switch in the basement has responded.

A storage battery with two motor-generator sets for charging is provided to supply current for the electric clocks, push buttons, emergency lights, etc. This plant is in the engine room and is controlled from a panel of the main switchboard.

The designers of the power plant had found that it was difficult to keep a power plant in an office building properly loaded when there was an electric elevator load and where ampere meters were employed to indicate the load conditions. The sudden and excessive demand for current that occurs when several elevators start simultaneously often causes a current flow much in excess of the generator capacity in service, and the tendency is for the operating engineer to throw more units into service to relieve the situation. The result of this is to underload the plant and cause poor operating conditions except for the two or three seconds that the excessive demand occurs. A special winding was built in the armature of the generators in this plant and this was connected to an instrument on the control board in such a manner as to indicate the temperature of the armature. It is well known that as long as the heating is not excessive the excessive overloads can do no harm, up to the capacity of the commutator, and it

is believed that this is a better method of determining the proper load than in placing reliance on ammeter readings.

The steam-driven auxiliary equipment, besides the air-blast fans, consists of two outside end-packed plunger pumps for boiler feeding and three small pumps in connection with the high- and low-pressure drip system, so arranged that any one of the three pumps can drain the blowoff tank or the dirty drip tank and discharge the contents into the sewer. Each of these tanks is provided with the usual cooling coils for the cooling of the water before it is allowed to run into the sewer. The returns from the heating system pass through vacuum pumps discharging into a return tank vented to the atmosphere. The return tank receives the high-pressure drips which are trapped into it, and the level of the water in the return tank controls the boiler-feed pumps by means of a pump governor of the float type. Raw makeup water is supplied to the return tank through manual control.



Transfer switchboard for throwing load on either service

The building is heated entirely by direct radiation, it being sufficient in all cases to balance the heat transmitted by the walls and windows. In a few of the officers' rooms and the large working space where many clerks are employed, automatic heat control was installed.

The building is equipped with a ventilating system handling a total of 1,477,000 cu.ft. of air per min., including supply and exhaust. The necessity for this was due to the plan of the building, which is a solid block without courts, which resulted in some of the working spaces being 60 ft. from the windows. Furthermore, the work of the bank requires the concentration of a considerable number of workers in larger areas. Of course, all space underground had to be thoroughly ventilated, also the kitchens for the officers and employees on the upper stories of the building. Ventilation was sparingly used in officers' rooms, where there was sufficient natural change of air to maintain proper air conditions. All the working spaces, however, on the ground floor and the typical floors above, were provided with artificial ventilation to prevent the unsatisfactory conditions that would exist if no such provision was made.

The ventilating equipment on a typical floor consists of two fanrooms, one for the east and one for the west half of the building, receiving air through the windows. Filters are employed to cleanse the air. It is then heated to room temperature only in stacks provided for the purpose and the temperature is automatically controlled. A motor-driven blower distributes the air through horizontal ducts above the hung ceiling and discharges it through registers so located that each bay of the building—that is, each area of about 20 ft. square and bounded by four columns—is individually equipped with a supply and exhaust register. The arrangement is such that the space can be subdivided in any way as long as the partitions run on the lines of the column centers, without interfering with the ventilating equipment. A similar set of exhaust registers is connected by horizontal ducts, also upon the suspended ceiling on each typical floor, to one or two main air riser shafts which are connected in the penthouse to a main-trunk exhaust duct from which six large exhaust fans capable of handling 216,000 ft. of air per minute, exhaust air through the roof. These fans are motor driven and are of the silent vane type, capable of being run in parallel and so controlled that any number can be used to meet the demand of the building.

There is nothing unusual in the electrical distributing system for lights, but an uncommon provision has been made for future extensions from the permanent equipment of the building originally installed for connecting push buttons, call bells, telephones and commercial machines where required at any individual and free standing desks. There are two main riser points throughout the typical floors for both light and low-tension equipment and conduits with low tension cables are run from these main shafts to boxes at various points around the outer wall of the building, the cables being connected to the usual telephone strips. These boxes in turn connect with an underfloor distributing system of fiber conduit in duplicate, one for low tension and one for light. These conduits are arranged in a grid and run on 5-ft. centers in an east and west direction with occasional cross-conduits in a north and south direction for interconnection.

Some facts in connection with the operating costs may be of interest. The total kilowatt-hours required by the building for the year 1925 was 3,154,010, of which 2,700,710 was generated and 453,300 purchased. The steam generated by the boilers for the year, according to the steam flow meters, was about 153,637,000 lb. Of this amount about 11,000,000 lb. was required for heating the building nights and for kitchen use. The steam evaporated per pound of oil was 13.81, and the oil consumed 0.5199 gal. per kw.-hr. when all oil was charged to the generation of electricity. If the steam used by the kitchen and for heating at night is deducted, the oil consumed per kilowatt-hour was 0.495 gal.

While the figures given cover the average for the entire year, it should be stated that the plant was put in operation only during the latter part of 1924 and that it had hardly found itself during the first six months of 1925. The operating figures were more satisfactory during the latter half of the year.

Messrs. York & Sawyer were the architects for the building. O. W. Ten Eyck is the manager of the building, and A. S. Vincent is the chief engineer.

The Diesel Engine's Position in American Industry

As Revealed by a Survey of Existing Installations

By L. H. MORRISON
Editorial staff, *Power*

IN THE never ending struggle to reduce power costs the possible application of the Diesel engine to various types of drives has commanded the earnest attention of engineers and managers. The question here to be answered is, Has this oil engine gained in popularity from this close scrutiny?

In 1921 *Power* made an extensive examination of the number of Diesel engines that had been manufactured in this country since 1898, together with the location of the units in the several states and in the separate industries. The assembled data were published in the March 1, 1921, issue.

Since that time the number of firms manufacturing Diesel engines has increased, as has also the yearly output, consequently it was felt that the survey should be reopened and data obtained to include up to 1926.

Owing to existing confusion in nomenclature, the term "Diesel" was taken as embracing only those engines that are cold starting, that is, requiring no application of a torch, punk cartridge, electric coil, etc., to obtain the initial ignition. This limits the number of Diesel manufacturers to thirty and excludes those designs generally termed "semi-Diesel" or "hot bulb."

In Fig. 1 is shown a graph giving the Diesel horsepower sold each year since 1898, while from the small insert graphs may be obtained the sales from 1920 to 1926 separated into stationary and marine units. The separation was not extended to include the earlier years, as the marine sales up to 1921 were only 43,000 hp.

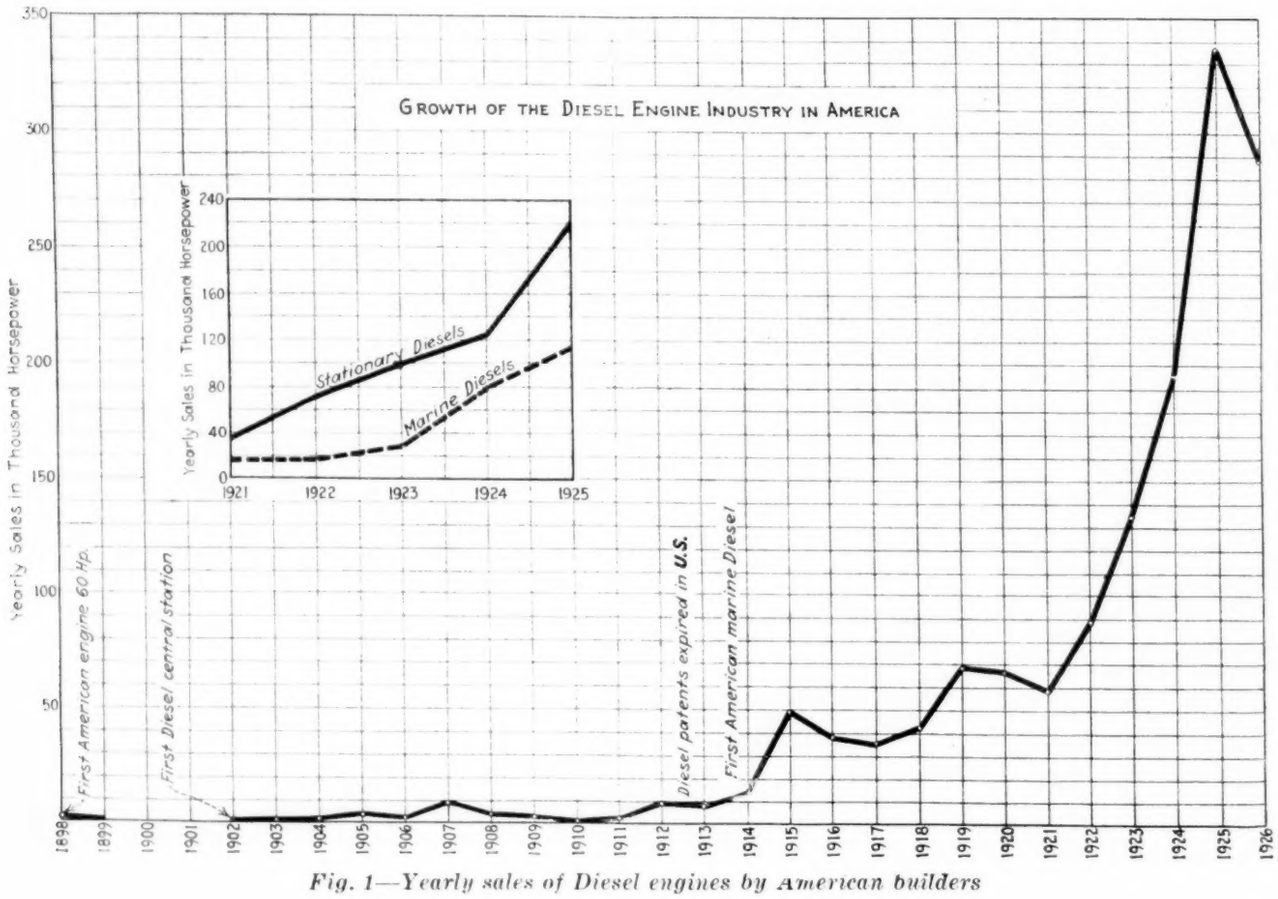

GROWTH OF THE DIESEL ENGINE INDUSTRY IN AMERICA
Yearly Sales in Thousand Horsepower
Yearly Sales in Thousand Horsepower
Stationary Diesels
Marine Diesels
First American engine 60 Hp.
First Diesel central station
Diesel patents expired in U.S.
First American marine Diesel

Fig. 1—Yearly sales of Diesel engines by American builders

Of the total sold, indications are that not over 20,000 hp. have been definitely scrapped, so that at present a total of 1,155,775 hp. of such engines manufactured by American builders is in operation.

This should serve to enlighten the engineering public as to the real depreciation to be expected from this type of engine. It was not until 1907 that the American

Diesel Engine Company began to build engines on a commercial scale, yet investigation reveals that even most of the units constructed in 1904 to 1906 are still in daily operation.

Attention is called to the fact that while the yearly

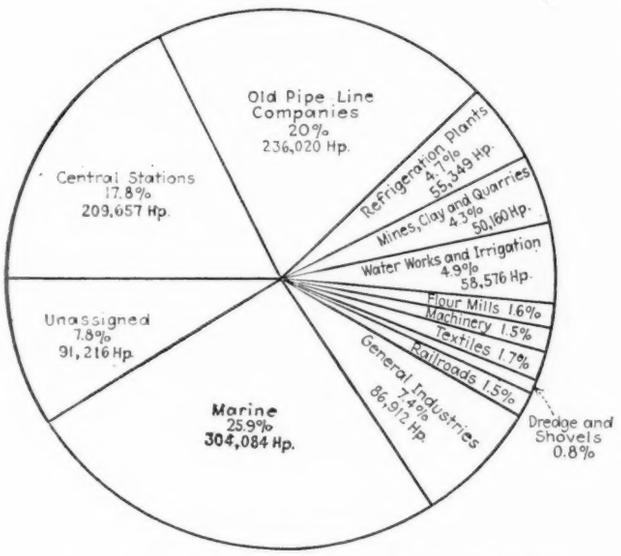

Old Pipe Line Companies 20% 236,020 Hp.
Refrigeration Plants 4.7% 55,349 Hp.
Mines, Clay and Quarries 4.3% 50,160 Hp.
Water Works and Irrigation 4.9% 58,576 Hp.
Flour Mills 1.6%
Machinery 1.5%
Textiles 1.7%
Railroads 1.5%
General Industries 7.4% 86,912 Hp.
Dredge and Shovels 0.8%
Marine 25.9% 304,084 Hp.
Unassigned 7.8% 91,216 Hp.
Central Stations 17.8% 209,657 Hp.

Fig. 2—Total sales separated as to industries

sales up to 1926 are based on accurate reports, the total shown in Fig. 1 and elsewhere for the year 1926 is founded in part on unauthoritative records and may contain some errors. It is barely possible that the last year's sales may approach more nearly those of 1925 than shown in Fig. 1. In examining the several charts, the reader should bear in mind that sales made one year, in several instances, have been placed in the succeeding year's totals. This occurs with part of the engines purchased by the Shipping Board and is due to the variations in builders' methods of dating a contract. A similar but insignificant error arose when tabulating engines the title of which passed only after all installment payments were made.

Development in the marine field has received far more attention during the last ten years than that in the stationary field, yet, as shown by Fig. 1, the yearly sales in the latter field have shown the greater increase. The total marine installed horsepower, as indicated in Fig. 2, is but 304,084 out of a total of 1,175,775, leaving 871,691 hp. as the total for stationary service. This, if not unexpected for the total power used by the industry, is far greater than the requirements of the Merchant Marine, which after all must compete with the more cheaply built foreign vessels. Outside of the Shipping Board's purchases for the Dieselization of existing steamers, most of the marine Diesels have gone into tankers, barges, etc., operating in coastwise and Lake service. In addition, the encroachment of the oil engine has impelled designers of marine steam equipment to go to high pressures, improved drives and more efficient power units, with the result that the efficiency of the steamer is rising steadily.

In Figs. 2 and 6 the Diesel installed horsepower has been segregated by industries and by usage. It is believed that these are approximately correct, but the exact values should not be used with the same confidence as may be those shown in Fig. 1. It is readily perceived that the exact duty an engine performs is, at times, most difficult to ascertain. For example, an engine in a flour mill may be delivering most of its power to an electric lighting system operating in conjunction with the mill, yet the records may classify the unit as being in a flour mill. Many other possible avenues for minor errors could be enumerated.

The charts show the wide application of the oil engine. It is impossible to list each separate industry using this type of power, and consequently under "General Industries" in Fig. 2 are set such widely different applications as fertilizer works and piano factories. The classification of "Unassigned" covers those installations where it was impossible to ascertain what duty was being performed by the unit. Such engines are in the main of small capacity, under 200 hp., and chiefly part of the output of a single manufacturer having a far-flung sales organization.

The survey revealed that a large amount, 17.8 per cent, or 209,657 hp., was installed in central stations. The greater part of these engines are in municipal plants, which is not surprising, as most of the central stations under 3,000 hp. capacity are municipally owned and it is in such plants that the Diesel shows to best advantage. The large holding companies have been purchasers of engines, especially for development work in rapidly growing communities. In fact the claim has been made that the oil engine was the basic factor that

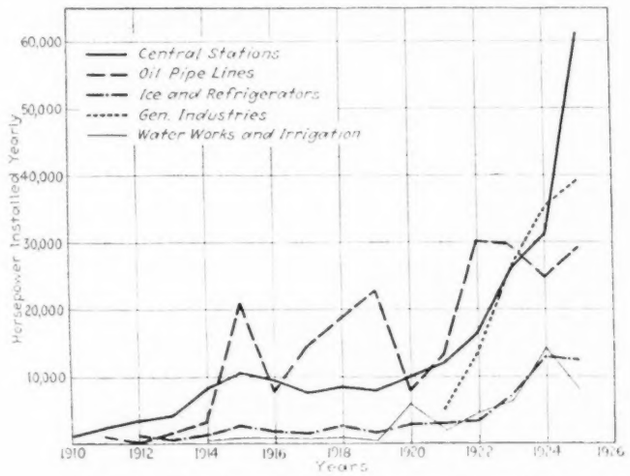


Fig. 3—Yearly sales in important markets

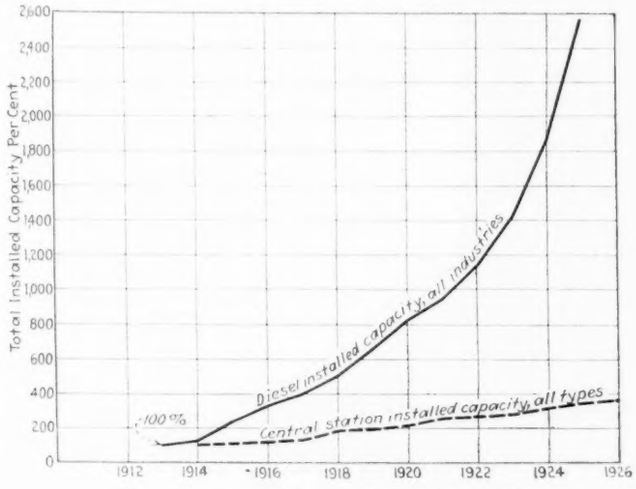


Fig. 4—Comparison of growth ratios

made the Florida boom possible. Communities developing over night created demands for electricity and other conveniences that were met by the installation of a small power plant, the capacity of which was increased from month to month by additional oil engines. That the creation of superpower projects has not illy influenced the Diesel is attested by the graphs in Fig. 3; it will be noticed that since 1920, when interconnection became a matter of common conversation, the sales of oil engines to central stations has shown a rapid increase.

The oil-pipe line companies first showed interest in the oil engine for pumping service in 1913, and after the initial troubles had been overcome, rapidly replaced existing steam pumping engines with Diesel units. Of the new pipe lines installed since 1917, all have been equipped with oil engines and it is almost unthinkable that any new system will ever install any power. Most of these units are in the mid-continental field, there being 170,000 hp. out of the total of 236,020 so located. The remainder is divided among the California, Wyoming and Eastern fields. These totals do not tell the entire story, for a considerable part of the horsepower classified as "Export" went into the South American oil fields. The fact that they were exported is, however, the outstanding feature, as it proves that the American manufacturer can meet foreign competition. In one instance the builder was faced with German competitors who had the advantage of cheap labor and low ocean freight.

Several classifications, such as "Railroad" and "Dredge," were absent from the 1921 survey. These new items are made necessary by the development of the Diesel locomotive and the oil-engine dredge and power shovel. These demands have led to the designing of light-weight high- and medium-speed engines, until 900 r.p.m. is accepted as feasible and weights of less than 50 lb. per horsepower are reached by more than one designer.

The electrification of many ice plants has apparently served to awaken owners of obsolete plants to the economic importance of cheap power, and this has encouraged the increased use of oil engines. The majority of the units going into the ice and refrigeration field

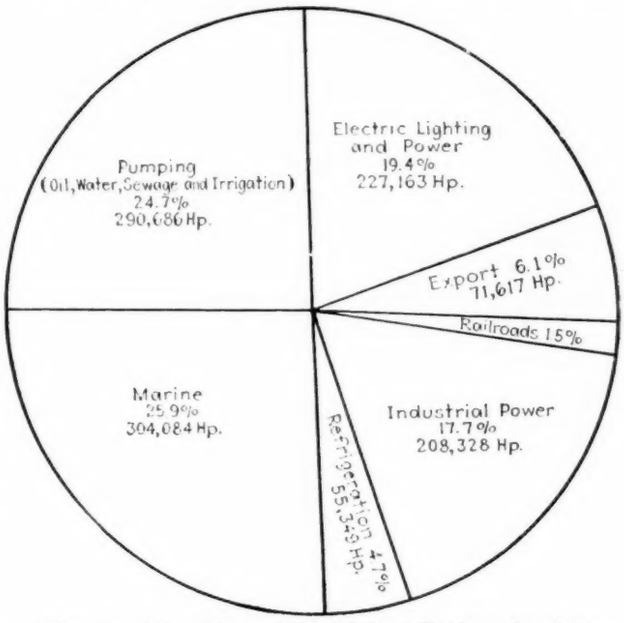


Fig. 6—Allocation of Diesel installations by duty

have been installed in new plants, for the application of oil engines to existing steam-driven compressors is difficult and electrification has been more generally adopted as the alternative.

In Fig. 2 the classification "Water Works and Irrigation" does not embrace the hundreds of semi-Diesel engines which are so evident in the Texas, Louisiana and Arkansas irrigation districts. The horsepower shown is for the most part assignable to water-works plants. However, much of the total listed as being in

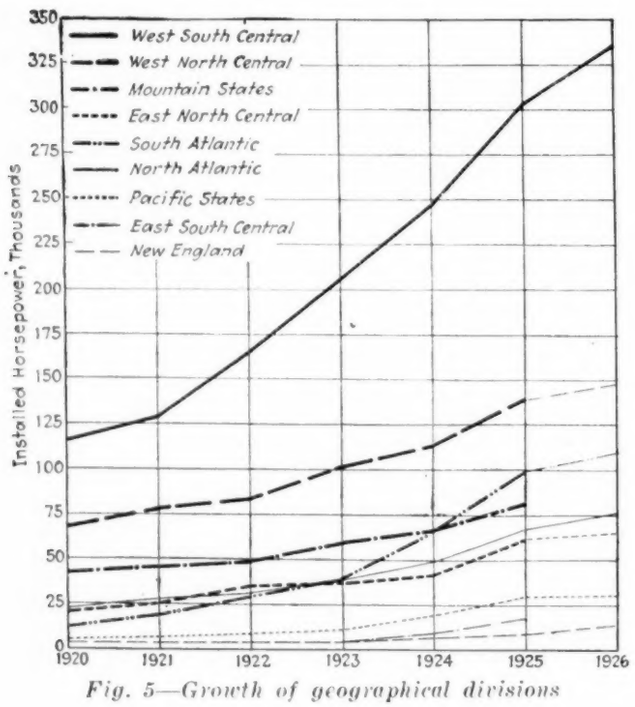


Fig. 5—Growth of geographical divisions

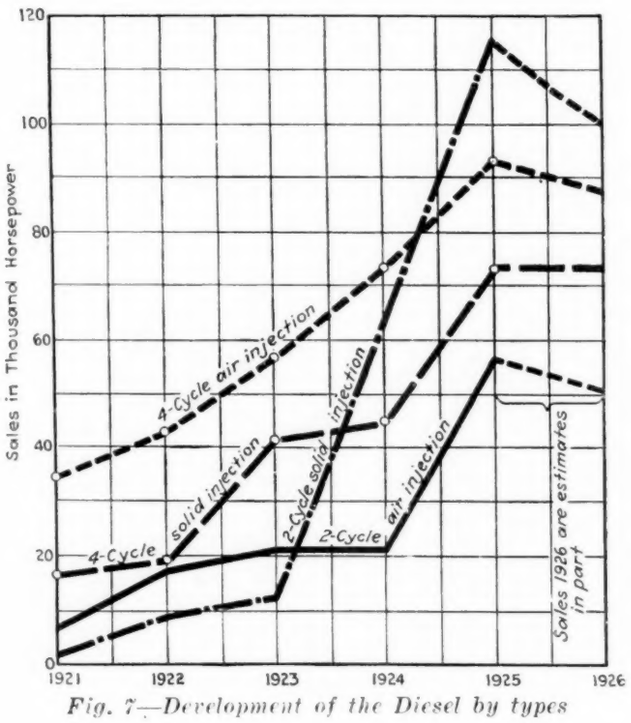


Fig. 7—Development of the Diesel by types

central stations is also supplying power to municipal water-works pumps in the same buildings.

The curves in Fig. 4 are the result of an attempt to show the increase in installed Diesel horsepower as compared to an industry that is admittedly in an exceedingly healthy growth. It will be noticed that while the central-station industry has experienced the remarkable growth in installed capacity of almost 400 per cent since 1914, Diesel installations have increased a total of over 2,600 per cent.

But the question arises, Is not the Diesel a type of prime mover that is installed only adjacent to oil fields?

While the four-stroke-cycle air-injection Diesel was the earliest type, the two-stroke cycle was adopted by several European builders to obtain a greater output per cylinder volume. Until 1921, excepting semi-Diesels and a few high compression engines, the use of airless injection or, as it is generally called, solid-injection, was not common. Those builders of four-stroke-cycle solid-injection units, overcoming the difficulties encountered with any new principle, rapidly found a market for their products. However, the same advantage in horsepower sold possessed by the air-injection type in 1921 has been retained throughout the several

Fig. 8—Map shows Diesel horsepower installed in each state

The curves in Fig. 5 are an attempt to answer this inquiry. While the West South Central States made up of Texas, Oklahoma, Missouri, Louisiana and Arkansas, show their predominating importance as Diesel markets, even New England is using about 11,850 hp. The South Atlantic States are using practically 100,000 hp. and in the North Atlantic States, where coal is comparatively cheap and steam central stations huge and efficient, there are over 60,000 hp. in use. The uniformity of growth of installed horsepower in each of these geographical divisions indicates a gradual acceptance of the internal-combustion engine by the country as a whole, rather than a temporary popularity brought about by a local cheapness of fuel oil.

The allocation by states of the engines sold since 1904 is shown in Fig. 8. It must be remembered, however, that in some instances, after installation in one state, engines have been removed to other states and even exported. Where the facts were known, the proper changes have been made, but it is impossible to state definitely that minor errors do not exist.

years. The two-stroke-cycle solid-injection engines show a startling development since 1923. This is due to the fact that in 1924 a builder of semi-Deisel redesigned his product to make it cold starting. Since the output of this builder is large, the curve for the two-stroke-cycle type mounts rapidly to a total for 1925 of 115,000 hp. It has been the large number of such units in sizes of 300 hp. and less that has held the average unit capacity of all Diesel engines to under 500.

As indicated, the sales for 1926 are partly estimates, and the only type not showing a slight loss is the four-stroke-cycle solid-injection. This is attributable to the developments in the railroad locomotives and to South American oil pipe lines.

Acknowledgment must be made of the assistance received from F. J. Murray of *Power's* research bureau in the collection of data. The many engine builders responded readily to the request for sales data, even though it involved considerable clerical work, and in several instances manufacturers threw aside traditional policies in the effort to make the survey complete.

Boiler-Room Inefficiency Often Fault of Plant Managers

By F. N. Ervine

It has been the writer's fortune in over twenty years' experience as an engineer to come in contact with a number of plant executives and engineers, mainly in connection with testing and developing boiler efficiency. In most cases the plant was small or of medium size, not large enough (according to the manager) to justify employing a competent engineer, so that the plant executive, in addition to his duties in the factory, had to supervise the work of the engineer, very much to the deteriment of the power plant.

Often enough, neither the engineer nor the plant executive had any conception of what boiler efficiency was or how it was obtainable. Their ideas were many and varied and ranged from the ridiculous to the fairly reasonable. They did not associate combustion with boiler efficiency, but thought that higher boiler efficiency would follow as a matter of course if the heating surfaces were kept clean.

I was discussing the various merits of a plant with one of the minor executives who claimed to be a technical engineer. He ridiculed the chief engineer of the plant for devoting the greater part of his time in the boiler room to improving the boiler efficiency by increasing the CO_2 content in the flue gases. This executive could not see in what way boiler efficiency could be improved by increasing the CO_2.

For some reason or other the chief engineer left the plant and was replaced by one of the shift engineers. Just previous to my taking charge of this plant, I had occasion to visit it again. It was interesting. The first thing I noticed was that every few minutes the fireman would strike with a hammer at the valve gear of the boiler-feed pump. I was informed that if he stopped the pump would stop also. The next thing noted was the CO_2 recorder. It indicated about 4 per cent and I was informed that, owing to the low setting of the boiler, it was impossible to do any better. The flue-gas pyrometer on one of the boilers indicated that the temperature of the escaping gases was about 950 deg. F. As I was leaving the engine room, the piston on the main engine pounded against the cylinder head. I was about to hasten my departure, but on second thought decided to see what would happen. Nothing happened; the chief engineer just glanced at the engine and let it go at that.

Although I had a free hand in making adjustments in this plant and was able to make a monthly saving of $800 almost from the start, the plant executive would not agree to employ a competent engineer and pay him a salary commensurate with his ability. He claimed that the size of the plant did not justify the increased expenditure. The chief engineer of this plant at that time was receiving 82½ cents an hour. I wondered how large a plant had to be before a chief engineer could receive a decent salary.

In other cases the human element was not taken into consideration in developing boiler efficiency. The management expected efficiency to follow automatically as a result of improvements in the plant equipment.

Recently, I was called into a factory, one of the largest in its line in this country, where the general manager complained of the condition of the power plant. It seems that he spent thousands of dollars in improvements, and that just as rapidly as these improvements went in, they broke down. I learned that the chief engineer of this plant was receiving 69 cents an hour. The general manager felt insulted when I suggested that he employ a competent engineer and pay him accordingly.

It has been my experience with a score of power plants ranging in size from 250 to 30,000 hp., employing small boilers, that the average boiler and furnace efficiency is about 45 per cent, where the boilers are set six feet above the grate and are horizontally baffled, or about 50 per cent where the boilers are vertically baffled. This state of affairs, I submit, is a reflection not only on the engineers that operate them, but even more on the executives who refuse to make expenditures for necessary improvements or to pay salaries that will attract competent engineers.

Cleaning Condenser Tubes

Laboratory experiments by the Elliot Company indicate that the proper acid concentration to use in removing condenser-tube scale is a 2.5 per cent solution by volume of hydrochloric acid for a treatment of one hour's duration. These laboratory tests further indicated that if it was more desirable, either from the viewpoint of economy or from that of time required to clean the condenser, a 1.25 per cent solution of acid could be used for a two-hour treatment, or a 5 per cent solution for a treatment of one-half hour's duration.

With regard to applying this method of acid cleaning of the tubes to actual practice, it is strongly recommended that the tubes be first thoroughly water-tested in order to avoid any possibility of getting acid into the condenser hotwell and subsequently into the boilers. As a further precautionary measure wherever feasible, periods of treatment should be longer, which will permit of a correspondingly smaller acid concentration. As far as the effect of the acid on the tubes themselves is concerned, there is little cause for worry, as the laboratory experiments revealed that a section of clean Muntz tube, when immersed in a 2.5 per cent solution of hydrochloric acid for one hour, experiences a loss in weight of only 0.038 per cent. This same test when applied to standard fiber packing showed that the packing did not decrease in weight in the least and did not deteriorate in any way, as far as could be observed.

The circulating water system in the 20,000-sq.ft. surface condenser with which this report is concerned, holds 46,500 lb. of water, or 5,580 gal. For a one-hour treatment 140 gal. of commercial hydrochloric acid should be used. This acid costs $1.85 per cwt., and 140 gal. would weigh about 1,390 lb. The cost of this acid, therefore, at the existing market price would be $25.75, or if it is desirable to use a two-hour cleaning period, this price would be cut in half, inasmuch as only one-half the quantity of acid would be required. It is, therefore, evident that this acid method of treatment is not only efficient, but also a cheap method to use.

FIGURES MADE PUBLIC RECENTLY by the Chicago & North Western Railway, which operates two Diesel-electric locomotives at the business pier district of Chicago, show a daily average of repairs of sixty-three cents for each locomotive, as against $16.20 for a steam locomotive engaged in the same work.

Reports That Discredit Their Makers

EVERYONE knows the plight of expert witnesses. The frequency with which experts have taken diametrically opposite points of view has led to suspicion and to such expressions as that striking crescendo, "Lies, damn lies and expert testimony." This tells at what cost of reputation some of the fat fees of the past have been won. Nothing so destroys the confidence of the layman as complete disagreement by experts on matters where approximate accord seems easily attainable.

A case in point in the power field is the making of reports on the advisability of purchased or home-made power. It is notorious that the analyses of various interested parties often differ enormously. One report will show that it is far cheaper to buy all power, while another will demonstrate with equal clearness that equipment to generate power locally will save its cost in two or three years. Such a case occurred recently in connection with a large new hotel, and it is typical of hundreds of others.

With such reports on his desk, both from engineers supposedly competent and honest, what can the owner do but throw up his hands and ask "Who's loony now?" Perhaps both reports are honest after a fashion. There are generally many factors that cannot be estimated closely. These give an opportunity for the exercise of conscious or subconscious bias. One man puts interest and depreciation too high; another places them too low or neglects them altogether. One over-estimates the additional coal and labor required for power generation; the other forgets all about rental value of space occupied. And so it goes in one detail after another until the final conclusions are as far apart as the poles.

For the sake of the good reputation of engineering, if for no other reason, it is greatly to be hoped that the parties to this ever-repeated argument may finally be able to agree on a few fundamentals, so that the reports submitted by opposing interests may be within gunshot of each other.

Diesel Industry Is Active

PROBABLY no other prime mover has been so surrounded with charges and countercharges as has the Diesel engine. In fact, no machine has received as much proportionate attention in the engineering publications and in the daily news columns as has this oil-burning engine. Unfortunately, much of this information has not been free from bias, and whether one is convinced that the Diesel is to become the predominating power generating unit or is a distinct failure, largely depends upon who is the second party to the conversation.

While data may be interpreted as the mood of the investigator may dictate, facts are facts and, when approached with candor, cannot be misunderstood. It was for this reason that a few years ago *Power* conducted a survey to ascertain the facts as to the number of engines installed, their horsepower and the like. Since the end of the War the number of firms engaged in the building of this type of internal-combustion engine has tripled, while the yearly horsepower has increased several hundred per cent.

This activity has prompted a continuation of the survey to bring it up to date, the results of which appear on another page. That over one and a quarter million horsepower are in operation at the present time may be taken as proof that the Diesel engine is of vital importance in the power-generation plans of this country. While it is natural to assume that the oil-burning engine would be most in evidence in the states adjacent to the oil fields, the survey reveals that no single state is without at least one installation. Apparently, it is an economical power even in those states where a network of transmission lines exists, although the low rates on the Pacific Coast seem to be a handicap even in the face of cheap fuel oil.

The amount of horsepower sold and the percentage of gain each year probably should not be taken as indicative of an unduly prosperous condition of the manufacturers. What the industry needs at the present time is less disturbance from the hasty formation of new companies to bring out strange or unusual designs.

Dished Heads— Why Not Make Them Right?

FOR years there has been an irrational element in the design of dished heads for pressure vessels, including boiler drums. The existence of this condition has been recognized after a fashion, but nothing much has been done about it. It is as if everybody agreed to act on the assumption that two and two make six, while readily admitting as an academic proposition that four is the correct summation.

Present custom calls for the design of a dished head as a portion of a sphere of a radius not greater than the diameter of the boiler shell. It is true that a complete spherical shell of this diameter, of the same thickness and subjected to the same fluid pressure, would show a fiber stress equal to that in the cylindrical shell. The trouble lies in the attempt to take a small portion of this spherical surface and attach it to the cylindrical shell by a knuckle of relatively small radius. The sudden reduction in radius at the knuckle sets up stresses far exceeding those in the shell. To put it simply, the knuckle tends to straighten out when pressure is applied.

The cure for such undue stresses is definitely known and needs only to be applied. Perhaps nothing more profound than the easy practice of "faking" ellipses with arcs of circles prevented its adoption years ago.

Both theory and experiment show quite definitely that the elliptical section is best.

That the ellipse is the natural form is indicated by the fact that heads of ordinary design tend to assume that contour when subjected to excessive test pressures. Consideration must, of course, be given to the proportions of the ellipse; that is, to the ratio of the depth of dish to the diameter of the shell. If it is not less than one-quarter, the maximum fiber stress in the head will never exceed that in the shell provided the manhole opening (where present) is properly reinforced. This question of reinforcement is just as important as that of head contour and much more difficult, but that is another story.

The point here is that the means are at hand to improve the design of boiler drums and other pressure vessels and that nothing visible stands in the way of adopting it at once, beyond the simple matter of making new dishing dies of elliptical section.

These thoughts were brought to life by the battery of papers turned loose on the subject last week at a combined meeting of welding and mechanical engineers in New York City (see page 72 of this issue), but *Power* need not plead guilty to recent conversion. In the May 26, 1914, issue may be found this statement: "As a matter of fact, any rule of the (customary) form assumes that the head is stressed as a sphere and is in consequence essentially incorrect."

If any reader can think of some good reason why dished heads should *not* be made of elliptical section, now is a good time to speak up.

Don't Ruin a Machine in Erection

MANY a machine is wrecked before it turns a revolution. At least one turbine failure was forestalled when somebody chanced to see the erectors drop the rotor from the crane to the floor. Superficial inspection showed no damage, but a close examination of bladings showed the beginnings of serious injury.

How often are turbines and similar high-speed machinery bumped or scratched during erection? How many erectors will tell about such occurrences? Things that seem to be insignificant may lead to a serious accident, and failure to report every untoward incident may be paid for by somebody's life. For the intelligent mechanic in charge of setting up a machine there is little excuse. He knows, if he is up to his job, that in high-speed rotative parts even a scratch on the surface may induce local concentration of stress that will result in a growing crack and final breaking of the rotor. He is responsible for the utmost care to avoid severe handling of such parts, and should regard it as his high duty to report anything abnormal in the machine or its handling, so that those better informed than himself may discuss the possibilities or at least have a full understanding of what they are doing when they assume responsibility for operating the machine.

But what is to be done with the ignorant laborer who accidentally drops a timber on a turbine shaft or wheel? It is futile to expect him to report his misdeeds. One obvious remedy is to keep the vital parts of a machine covered up securely except when they are under the direct observation of skilled men who are on the alert to prevent any damage to the machine under their care.

A helpful device is for the plant management to detail the operating engineer to watch the erection of new machinery and to authorize him to interfere with the work when he considers it necessary. In the building of a new plant the man selected to operate it makes a splendid observer, a sort of super-inspector. If he has authority to stop construction when he sees things going in that he knows will have to be changed before the plant can run smoothly or safely, expense and danger are reduced. An intelligent man can be trusted not to interfere needlessly.

Whatever the method, the result must be secured. As far as it is humanly possible, the engineer must know with certainty that his machinery comes under his care without injury that is not known to him.

Condensing Surface a Diminishing Factor

ONLY a few years ago it was common practice with the steam conditions then existing in power plants, to install condensers with two to three square feet of cooling surface per kilowatt-hour. A study of the central stations that have recently been put in operation reveals that the present practice runs from one to one and one-half square feet per kilowatt, while some plants have even less than a square foot per kilowatt.

Much of this improvement has been due to developments in the condenser design, to better utilization of the cooling surface, more certain air removal, and improved steam distribution. Recent discussions indicate that further gains may be made in these and other directions.

Recognition should be given to the effect of higher steam pressures and temperatures in lessening the total steam required per kilowatt in steam turbines and hence lessening the heat per kilowatt-hour that is discharged to the condenser. The use of bleeder heaters also has considerable effect on the amount of cooling surface required in the condenser. For instance, a recent paper shows that with twelve hundred pounds pressure seven hundred degrees F. temperature, twenty-nine inches vacuum and four bleeders, the steam discharged to the condenser is eighteen per cent less than if no bleeders were used. This will effect an appreciable reduction in condenser surface. The combined effect of high pressure and bleeding is also brought out forcibly by the following figures: Each pound of steam at these high-pressure conditions supplies about 1,275 B.t.u. to the turbine, of which 305 B.t.u. is converted into work, 400 B.t.u. is absorbed by the four bleeder heaters and 570 B.t.u. only is discharged to the condenser.

When one recalls that 950 B.t.u. was the value usually assumed for the heat to be removed per pound in a condenser operating under former low-pressure plant conditions, it is evident that condensers will occupy a diminishing sphere of influence in the new high-pressure, high-economy plants of the future. This will also lessen the auxiliary power required for condenser purposes.

While condenser surface is diminished under the new conditions, additional heat transfer surface must be provided with the turbine in the form of heating surfaces in bleeder heaters. The temperature differences in these heaters are several times that existing in a condenser. Hence, relatively less surface is needed to effect the heat transfer, although the pressures at these points will demand heavier and more expensive tube construction.

Ideas From Practical Men

Readers are urged to use this department for the exchange of practical operating information. A minimum of five dollars will be paid for contributions accepted

Hiring and Discharging Help in the Power Plant

A good deal has been written upon the subject of hiring and firing in the power plant, but most of this, being from the point of view of the losses incurred by these changes, must I think contain a lot of guesswork. It is usually assumed that every time you fire one hand and hire another there will be a loss for one's firm, but a little reflection should suffice to convince one that this is far from being a fact.

Not long ago I was compelled to discharge a fireman. He had been a long time about the place, too long in fact, as he thought he owned it, which was the principal reason for moving him on. He appealed to the powers that be and, while they advised reconsideration on my part, I carried my point, and his successor, after the first week, more than saved his wages in our coal bill alone, while the firm, instead of having a man in a groove, have a smart young man on the alert all the time for advancement and anxious to oblige everyone about the place. Of course, some will say this is an exceptional case, but I do not think so; similar ones could undoubtedly be found in many other plants.

The man in a groove about a power plant is better in every way for a change, and shifting such men can only result in gain to the company, never loss. I do not mean that men who have grown old in the service of the firm should be hustled out under any available excuse, generally their long experience is still valuable.

The plant engineer who looks upon changing men solely as a loss is himself badly in need of a change, as it is quite evident such a man is at a standstill and afraid to move because of this bogey. Although needless changing of one's staff is not advisable, it is a different matter when one has a definite object in view. Many discharges may have to be made before the right man gets in the right place. Sometimes we have labor troubles apart from the men. Quite recently, the young lady clerk who was my special property, resigned, and I thought she could not be replaced without considerable trouble. Her successor came along with piles of references and appeared to have previously done her work most satisfactorily, and in about seven languages, but while with me I never discovered any language that would convey to her mind the knowledge that our motors did not run about the streets on four wheels, or that we did not boil clothes in our boilers, and no matter how I tried she showed no interest in power-plant work and at my suggestion she gave up the attempt. In her place I obtained a girl direct from school without references except from her schoolmaster, and from the first day I saw that power matters would interest her, and within a short time she was even more proficient than the one I thought could not be replaced.

Such incidents have always been happening in power plants and other businesses, and it is to be hoped in the interests of progress they always will, and the less said about the losses in labor changes the better. The man who is always looking for a loss is pretty sure to find it.

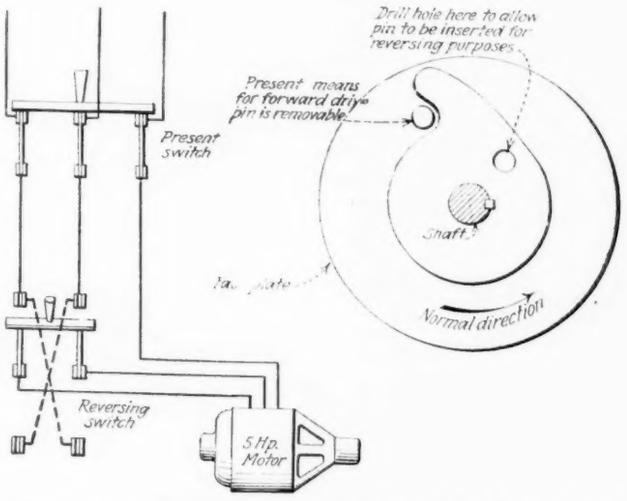
F. P. TERRY.

Belfast, Ireland.

Changes Made in Stoker Drive To Facilitate Driving Grate Backward in Emergencies

Every once in a while something will happen to a traveling-grate stoker even if every precaution is taken to maintain it at its highest efficiency, and quite often in such cases the reversing of the grate for a few inches will clear the obstruction.

In order to move the grate backward by motor, not only do provisions have to be made for reversing the motor, but a method must be provided for driving the grate backward, the usual means of doing this being


Drill hole here to allow pin to be inserted for reversing purposes
Present means for forward drive pin is removable
Present switch
Shaft
Normal direction
Reversing switch
5 Hp. Motor

Reversing switch in motor circuit and locking pin in stoker mechanism permit driving grate backward

the employment of a large wrench with about three men on the handle. It can be accomplished by motor as follows:

A two-pole double-throw switch is inserted on two phases of the three-phase circuit leading to the motor, and connected as indicated by the dotted lines to give rotation in either direction. As the driving mechanism on the stoker is designed to drive in one direction only, provision has to be made for locking the driving disk and faceplate. This can be done by removing the regular driving pin from its normal position and inserting it in a hole drilled through both plates, as shown. This permits the grate to be driven backward by the motor and makes the operation of the stoker much more flexible than before.

E. J. MORRISSEY.

Aurora, Ill.

The Design and Operation of a Blowoff Tank

As inquiries appear from time to time in the columns of *Power* as to a rule for determining the size of a blowoff tank, I should like to contribute some suggestions from experience with blowoff tanks, which may throw some light on this subject.

The blowoff tank is provided as a low-pressure chamber usually vented to atmosphere to receive and cool the boiler blowdown before it passes to the sewer.

It has been the practice of the Detroit Edison Co. in its central heating plants to use blowoff tanks and to cool the blowdown with cold city water before it enters the tank. It has been demonstrated that if this cooling action is not sufficient, the tank is subjected to objectionable hammering.

The following, with the illustrations Figs. 1 and 2, describes briefly a typical blowdown apparatus which takes care of a plant with six boilers totaling 120,000 sq.ft. of heating surface and operating at 160 lb. gage.

The blowdown enters the tank tangentially through a special siphon fitting (Fig. 2) to which the city water at 40 lb. gage and an average temperature of 52 deg. F. is supplied. Originally, the city water was supplied to the bottom of the tank, from which it was drawn in with the blowdown through the action of the siphon

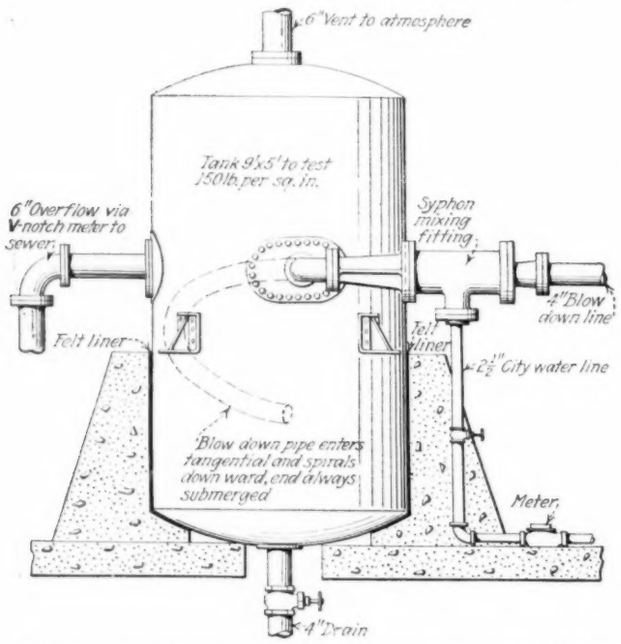

6" Vent to atmosphere
Tank 9'x5' to test 150 lb. per sq. in.
6" Overflow via V-notch meter to sewer
Syphon mixing fitting
4" Blow down line
Felt liner
Felt liner
2½" City water line
Blow down pipe enters tangential and spirals down ward, end always submerged
Meter
4" Drain

Fig. 1—Arrangement of blowdown tank with siphon fitting and connections

fitting. The reduced cooling effect at the siphon fitting owing to supplying a mixture of blowdown and city water caused serious hammering. The siphon line from the base of the tank was then closed and cold city water supplied direct to the siphon fitting, after which the operation was noiseless.

Both the city water and the total discharge from the blowoff tank are metered, and results show that on the average the city water used is about three times the actual quantity blown down.

A typical meter chart on the blowdown shows the amount of city water flowing continuously during the period of blowing down at about 120,000 lb. an hour, each blowdown raising the indication to 220,000 lb. per hour for about one minute, with two minutes elapsing between blows. This chart, when computed by planimeter, reveals the relation of city water to blowdown as about three to one, whereas at the instant of blowing a valve the rate of flow of blowdown and city water are about equal. The resultant temperature of 132 deg. of

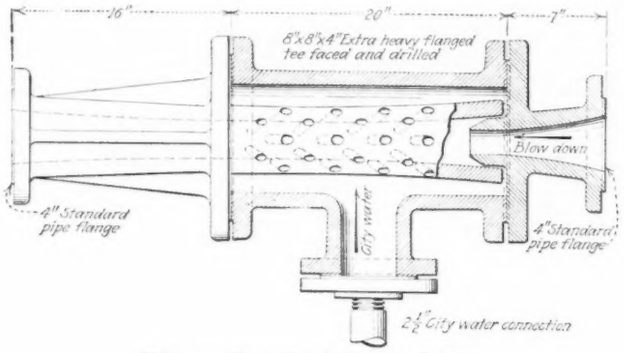


Fig. 2—Detail of siphon fitting

the water going to the sewer would indicate an excess of city water over what is required.

Example:

Heat of liquid at 160 lb. gage	343	B.t.u. per lb.
Heat of liquid at 132 deg. F.	100	" " " " "
Heat lost to city water	243	" " " " "
Heat of liquid at 132 deg.	100	" " " " "
Heat of liquid at 53 deg.	21	" " " " "
City water absorbs	79	" " " " "

243 ÷ 79 = 3.075 lb. city water per pound of blowndown, which checks the ratio of metered quantities.

It is not necessary, however, to cool the blowdown as low as 132 deg. Theoretically, a pound of city water under these conditions is about all that is required per pound of blowdown:

Heat of liquid at 160 lb. gage	343	B.t.u. per lb.
Heat of liquid at 212 deg.	180	" " " " "
Heat given up to prevent flashing	163	" " " " "
Heat of liquid at 212 deg.	180	" " " " "
Heat of liquid at 53 deg.	21	" " " " "
Heat gained by city water	159	" " " " "

163 ÷ 159 = 1.026 lb. city water per pound of blowdown.

However, in the case previously mentioned, the city water flowing continuously at approximately the same rate as the blowdown, the latter being intermittent, causes the ratio of 3 to 1 and the resulting temperature of 132 deg.

As to the tank itself, since its function is simply that of a closed chamber at atmospheric pressure floating on the line between the sewer and the blowdown line, its size is of little importance provided the overflow pipe is adequate as to diameter and level above the sewer connection to handle the total amount of blowdown and cooling water. If a drain cannot be provided large enough to handle this rate of flow, it would be quite simple to figure a tank of dimensions such that the rising level in the tank, due to the incoming blowdown, would not reach the top in the length of time required to blowdown one valve. The level could be allowed to recede again to the overflow level before opening the next valve.

C. T. VAN DUSEN.

Detroit, Mich.

Comments from Readers

Middle Age and Opportunity

I have been much interested in the articles that have appeared recently in *Power* on "Middle Age and Opportunity," and I doubt if I can add much to what has already been said, but I cannot resist the temptation to say a few words at least.

Unfortunately, I did not have the opportunity to attend college, but if we are to be relegated to the scrap heap in the very prime of life, as some would have us believe, I doubt if I have missed much. In 1896, after teaching in a country school, I entered the old regular army with the intention of gaining a knowledge of the rudiments of engineering. I did not hesitate to make my wants known and found the officers always willing to help me. Upon my discharge in 1902, I was well prepared to cope with the ordinary subjects of the profession and have been actively engaged ever since along the same line.

Sometimes I think one should take stock of himself occasionally, and the following questionnaire seems to fit into the present subject very well in this respect: How old are you? How long have you prepared? What were your subjects? Do you practice your knowledge? Have you been successful? Have you held good positions? Do you like engineering? Have you saved for a rainy day? What will you do when retired? Why don't you quit? What is wrong?

May I offer a suggestion? Perchance no one will take exception, and it may prove a guide to some of our younger men.

It seems to be the prevailing sin among our students entering upon life's work to accept any old job at any old price. While there is logic in such a practice if accepted by both employer and employee in good faith, I am inclined to think the employer commercializes sometimes upon the anxieties and ambitions of the student employee, to the extent that in the end the student injures himself financially and lowers the dignity of the profession and those already established.

Mr. Gibbons, in his letter in the Nov. 23, 1926, issue, seems to have hit the nail on the head when he cited the tendency of the employer to refuse employment to men past 50 or 55 because of releasing them a few years later without means of support or a pension. At first thought that seemed plausible and answered the question satisfactorily, but let us give it further consideration.

Practical experience is undoubtedly the best teacher, and after a busy life during which I have employed and had charge of large numbers of men, I find that men who have lived a good clean life up to 60 or 70 years of age are in many instances preferable to the younger class.

There is still another solvent in this matter that tends to explode the whole works and prove the falsity of our present foolhardy method, and that is the results achieved during the World War. One must remember that our young mechanics, engineers, scientists, etc., were called from their studies, shops and laboratories to meet the needs of those terrible days. At home, in the same shops and laboratories were employed those above 40, 50, 60 and possibly 70 years of age. Our industries were never put to the strain before or since to meet the demands. The results speak for themselves. These matters need just the publicity they are receiving and I hope a more broadminded vision may come to those responsible for many of the present conditions.

Kokomo, Ind. ARTHUR C. HERREN.

Why Is the Vacuum Low?

Referring to the inquiry of A. W. Napier in the Nov. 16 issue "Why Is the Vacuum Low?", it would appear, from the readings given, that the trouble is shortage of circulating water. As will be noted, there is about one-third load on the unit, yet there is from 20 to 26 deg. rise in the temperature of the circulating water. It can be easily seen what would take place if the condenser were fully loaded, as condensers are generally designed for a circulating-water temperature of 70 deg. When the temperature water is much above this point and the amount of circulating water is reduced or throttled, the condenser does not function properly owing to improper distribution of the small amount of water; also, in such cases the vacuum pumps are forced to handle considerable hot vapor or steam, which reduces their capacity enormously.

Conditions regarding vacuum are sometimes benefited by having a spray of cooling water injected into the suction pipe of the vacuum pump. This cooling water will act as a condensing medium for the steam that is being drawn into the pump and will also cool the air, allowing the pump to carry a considerably larger flow with an appreciable increase in vacuum.

It may be possible that the circulating water pump is not functioning properly, as a rough check on the temperature shows less than 1,500 gal. of water per minute is being pumped. JOHN F. HURST.

Louisville, Ky.

The data submitted by Mr. Napier point to an excessive air leakage or almost complete failure of the dry vacuum pump to function. It does not, however, account for the high temperature of the condensate. The readings under this heading look as if they were taken in the exhaust pipe leading to the condenser rather than in the hotwell.

A test of the dry vacuum pump would aid in locating the cause of the trouble. This could easily be done by blanking off the suction at the pump and inserting a nozzle or orifice of suitable size for the capacity of the pump. If this test proved that the pump was all right, then the turbine seals and all pipe joints as well as the turbine casing flanges at the vacuum end should be inspected.

Should there be no dry vacuum pump and only a wet vacuum pump is used, it would be well to make sure that the pump valves are in good condition and that the

spring tension on the valves is practically the same as it was originally. Too much tension would not allow the pump to free itself of air at high vacuum.

The circulating pump readings would indicate that the pump was not pumping to capacity, but that it was pumping ample for the load.

Low vacuum would of course be responsible for a higher water rate on the turbine, which in turn would cause the temperature of the discharge water to go up. Nevertheless, a vacuum of 26 in. at least should be attained without difficulty. I believe excessive air leakage or failure to handle the air is the principal cause of trouble.

WILLIAM F. O'REGAN.

Boston, Mass.

Beware of Portable Electric Lights in Boilers

The editorial in the Nov. 23, 1926, issue entitled "Beware of Portable Electric Lights in Boilers," is deserving of a great deal of thought by readers of *Power*, because it concerns the safety of workmen. One of the safest arrangements I have seen for use inside a boiler was a 200-watt vaporproof fixture mounted on an arm with a pipe tripod standard and all the wiring in pipe. When the manhole was opened, the lamp-stand arm was pushed into the drum and the workman could slide in past the pipe and have plenty of light to see to do his work.

Another satisfactory arrangement was B.X. cable with a standard waterproof marine portable fixture with guard and hook. In one tube on each end of the drum a wood standard had been set up about 3 ft. high and a ½-in. rope stretched from one standard to the other. On this rope the light was hung, and it could be pushed to whatever position needed. This B.X. cable makes a substantial cord that will stand abuse, and where a three-conductor cord is used, with the fixture shell thoroughly grounded, there is little danger of shock.

Another hazard that receives little attention from workmen is an electric drill or other tool operating on 110-volt alternating-current three-wire lighting circuits. Many electric drills are fitted with a red wire for grounding and many factories are insisting on three conductor cords on all drills, nevertheless workmen are still badly hurt owing to the fact that drills are being operated on three-wire circuits with the drill and neutral wire not properly grounded, so that under certain conditions the workmen can get shocked at a potential of 220 volts.

Safety precautions are too frequently accepted as a necessary evil, and it often happens that the employee who is warned the most about being careful gets hurt because he is too obstinate to accept the safety inspector's advice.

This calls to mind an instance where an employee was saved from more serious injury by a safety switch cover being locked shut. It was on a 75-hp. inductor motor. The workman made a practice of pulling the switch without tripping the compensator first, and the switch blades became badly burned by arcing. A sign was painted on the safety switch, "Always trip compensator before pulling switch," but to no avail, for the workman persisted in doing it in his own way. This motor was driving a direct-current generator on a battery-charging outfit, and one day this workman pulled the switch with 75 amperes on it and the confined gases from the arc blew the cover open and the flash singed his hair and eyebrows, so now he is one of the best safety-first men in the factory.

Modern high-tension work is quite carefully guarded and disconnect switches are usually grounded on the dead side when men are at work on equipment to which they connect. Most companies require chains on high-tension lines while work is being done on them, but the average workman on low-voltage circuits does not seem to realize that he can be badly, even fatally, hurt.

Chicago, Ill. CARL WILDEY.

Alcohol Keeps Plant Apparatus from Freezing

The article by Frank T. Ward in the Nov. 23, 1926, issue, "Alcohol Keeps Plant Apparatus from Freezing," is a timely one at this season of the year.

When using alcohol or any of the anti-freeze solutions, a certain amount of caution should be taken when preparing the solution and also when opening up the apparatus for cleaning or inspection, as cases have been known of men being injured through explosions when naked lights have been used, or being overcome by gas fumes.

The anti-freeze mixtures in the following table have given satisfaction. For best results a hydrometer should be used and the water and alcohol should be well mixed.

WOOD ALCOHOL AND WATER SOLUTION

Temperature	Per Cent Water	Per Cent Alcohol	Specific Gravity
10 deg. F. above zero	80	20	0.969
Zero	75	25	0.963
22 deg. below zero	60	40	0.951

If denatured alcohol is used, 15 per cent more is required as its freezing point is 10 deg. higher than wood alcohol.

GLYCERIN AND ALCOHOL SOLUTION

Temperature	Per Cent Alcohol	Per Cent Glycerin	Per Cent Water
15 to 30 deg. F. above zero	10	10	80
Down to 5 deg. below zero	15	15	70
Down to 15 deg. below zero	17	17	66

Winnipeg, Man. O. G. A. PETTERSSON.

Prolonging the Life of Furnace and Ashpit Doors

Referring to the letter in the Oct. 19, 1926, issue, by W. H. Wakeman, on "Prolonging the Life of Furnace and Ashpit Doors," I have witnessed some firing such as he describes, where the fireman shoveled the coal into the furnace until it ran on the floor, and then threw several lumps on the dead plate for good measure. In this particular plant the doors were warped until they would not shut by an inch. With reference to the long life of furnace doors and linings, I know of several sets that have been used 30 years and are seemingly as good as the day they were put in service. They are of heavy construction and have linings about ⅜-in. thick with openings the shape of a cross in the center. Mr. Wakeman speaks of furnace-door linings not being perforated sufficiently, and for that reason they burn out in a short while. I believe that perforating door linings can be carried to extremes. I have seen linings that were about all holes, and they lasted only a short time.

Another theory that in my opinion does not work out

in practice is that when the ashpit doors are closed and the damper left open, the grates are burned and warped. I do not believe that the grates are any hotter when the ashpit doors are closed than when the damper in the stack is closed, provided the damper closes tight and is not just a makeshift. Clean coal or coal with a small percentage of ash, say below 6 per cent, also the frequent shaking of the grates, keeps the hot coals in contact with them, and even if the boilers are not forced beyond rating, the grate repair bills will be high. I know of one large service company that stopped using a high-grade low-ash coal on account of excessive grate repairs.

Keeping the grates comparatively clean of ash and clinkers tends to shorten their life. One has only to observe that the front section of the grates burn out much more quickly than the back sections. This is caused by constant stoking of the fires in front, which keeps the grates clean, while the back end is protected by a deposit of ash and clinker. Where grates are used that can be reversed, changing them when the front ends get pretty well burned out will prolong and sometimes even double their life. J. W. STEPHENS.

Staunton, Va.

Arranging a Belt Tightener in a Limited Space

Referring to the article in the Dec. 14, 1926, issue on "Arranging a Belt Tightener in a Limited Space," I doubt if the arrangement shown would prove to be satisfactory.

The weight is suspended from a sheave hung on a shaft of considerably smaller diameter than the sheave. Wound around this shaft is a cable that forces the tightener to bear against the lower side of the belt.

My opinion is that the shaft is so small that the tightener will move in one direction only, and that is, upward. It will not move downward and lift the weight whenever there is a change in belt tension caused by variation in humidity or variation in load. This, therefore, is a point against it. The arrangement would always have the tendency to make the belt tighter. During a sudden peak load the weight would pull the tightener upward, and there it would stay, maintaining the belt in its extremely tight condition during the following low load. W. F. SCHAPHORST.

Newark, N. J.

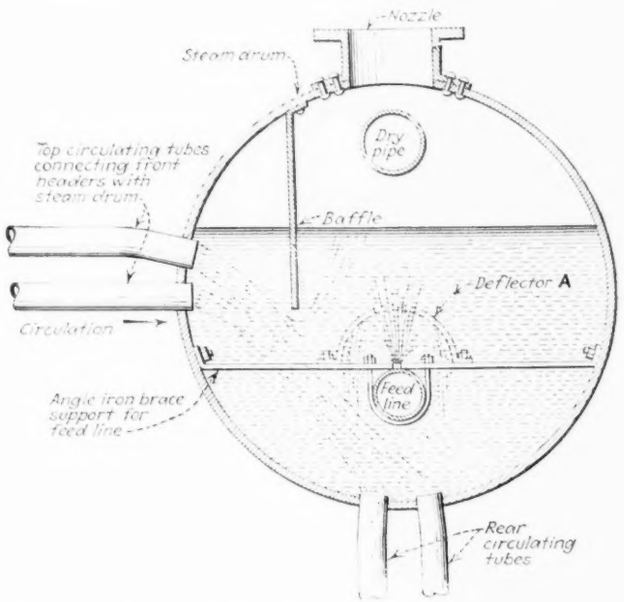
Why the Tubes Burned Out

The data given in the letter by Elliott E. Smith in the Dec. 21, 1926, issue on "What Made the Tubes Blister and Burn Out," is somewhat incomplete, but from the information given I draw the conclusion that steam locking is the cause of the trouble and that changed operating conditions rather than the attachments placed in the drum are responsible for the apparent minimization of the tube trouble.

In a boiler of this type the bottom tube of each row generates the greatest amount of steam. This is delivered to the front header in which it rises. At the level of the second tube more steam and water are discharged and so on until the output from probably 14 to 24 tubes is passing into the header. This crowding or hydraulic friction is further augmented by forcing the entire output through the two circulators to the drum.

The result of this friction in the water path is that steam is dammed up to some extent in the bottom tube, where it insulates the tube wall from the cooling effect of the water and allows the tube to blister even if perfectly clean.

The baffle in front of the circulators, as shown in the illustration reproduced herewith, interposes additional friction in the water path and is strange treatment for the disease of sluggish circulation. Nothing has been said about the character of the load, but if it is subject to sudden demands, the steam pressure will drop, especially in a one-drum boiler with water carried as high as shown in the illustration. With a drop in pressure some water in the tube tanks will flash into steam with two possible courses of travel to the drum. The path up the rear circulators is so much shorter than via the top circulating tubes that it is logical to believe that



Cross-section of boiler drum showing arrangement of circulating tubes and feed pipe

some of this flash steam takes this path and opposes the circulation, perhaps in some cases even bringing it to a standstill.

This boiler probably has about 500 sq.ft. of heating surface per foot of furnace width, which will require about 0.007 cu.ft. of feed water per second for each foot wide. There are perhaps three 3½-in. rear circulators per foot, and if the feed were sent directly into them, the velocity would be at rating about 0.5 ft. per sec. This is so low that it should have no appreciable effect on the boiler circulation.

My explanation of the improved condition is either a reduction in the load carried on the boiler, or the maintaining of a more uniform load and consequent reduction of the relief-valve action and reversal of circulation. This will also account for the drier steam, as the water shot out of the rear circulators is thrown into the steam space and this materially increases the wetness of the steam.

If Mr. Smith will tell the character of the load and whether the damaged tubes sagged or humped, it will be of assistance. E. S. SMAIL.

Oak Park, Ill.

Revolution in Dished-Head Design Foreshadowed by New York Meeting

Test Reports Show Present Designs To Be Irrational and Weak at Knuckle and Manhole—Replacement of Castings by Welded Structural Shapes Discussed

RADICAL changes in the customary designs of dished heads for boiler drums and other pressure vessels may be a possible outcome of papers delivered at a joint meeting of the Metropolitan (New York City) sections of the A.S.M.E. (machine-shop practice division) and the American Welding Society on Tuesday evening, Jan. 4.

About two hundred engineers attended the gathering, which was held in the Engineering Societies Building. Four papers presented by members of the research staff of the Union Carbide & Carbon Corporation and subsidiary companies revealed a mass of evidence, both experimental and analytical, tending to show that present standards for dished heads, as covered by the A.S.M.E. boiler and unfired pressure-vessel codes and exemplified by current practice, are irrational and make the heads weak points in drums and pressure vessels so constructed.

These reports were preceded by a paper, "Replacing Castings by Welded Structural Shapes in Machine Design," presented by W. L. Warner, of the Industrial Engineering Department of the General Electric Co. W. F. Dixon was chairman of the meeting.

Mr. Warner mentioned the school maintained by the General Electric Co. to train its own welders. This corporation is said to save more than a million dollars yearly in its manufacturing processes by the extensive use of welding.

Mr. Warner pointed out that three-quarters of the country's entire output of iron products is steel in one form or another. The growing use of steel fabricated by welding to replace castings will still further increase this proportion, he said.

Among the advantages listed by Mr. Warner for welded machines, fixtures and tools are: Smaller sections and hence less weight for the same strength and stiffness, cost per pound less than half that of cast iron, no patterns or pattern storage, elimination of loss due to defective castings and less waste allowance for machining.

Compared with riveted structures, said Mr. Warner, welding makes it possible to work from one side only, eliminates the weakening effect of rivet holes and the necessity for connecting pieces, and makes possible the building up of a thick joint much stronger than the body of the structural section.

His slides showed many interesting fabrications made by welding in the General Electric shops. Among these were: Gears built up of forms torch-cut from thick plates, bending dies, machine bases fabricated from Z-bars, plates and other structural sections; field frames of alternators designed for steam- and water-turbine drive and of synchronous condensers, etc.

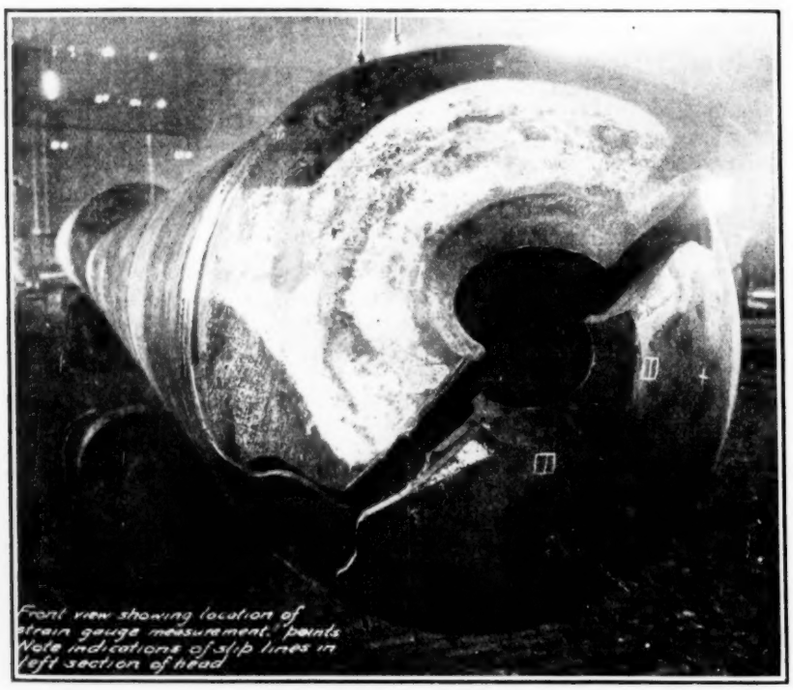


Fig. 1—View of tank after the head failed at a test hydrostatic pressure of 930 pounds

This was preceded by two tests to 1,000 lb., each of which gave a permanent set to the manhole.

Dished-Head Design a Byproduct of Welded Pressure-Vessel Study

Mention has already been made of the group of four papers centering around the design of dished heads for pressure vessels. The speakers were S. W. Miller and A. B. Kinzel, of the Union Carbide & Carbon Research Laboratories, Inc., and H. E. Rockefeller and T. W. Greene, of the Linde Air Products Co., a subsidiary of the Union Carbide & Carbon Corp. All these papers sprang directly or indirectly from the problems encountered in the design, construction and testing of a tank 5 ft. in diameter and 43 ft. in length for the storage of ethylene under 300 lb. pressure.

The following is a composite abstract of the four papers, covering points of special interest to *Power* readers and interpreting the findings of the authors as understood by the reporter.

Tank Designed for 300 Pounds

In the early part of 1926 a demand arose for the storage of a considerable amount of gas at 300 lb. pressure. Although the tank requirements necessitated the use of heavier plate than had ever before been commercially gas welded in tank fabrication, the Carbide & Carbon Chemicals Corp., for whom the tank was made, did not hesitate in specifying oxyacetylene welding.

The storage requirements called for a tank 5 ft. in diameter by 43 ft. in length. The 1¼-in. shell thickness was based on a design fiber stress of 8,000 lb. per sq.in., the same as employed in previous construction for this company. In designing the heads, however, several changes were made in the layout previously used. To provide a more satisfactory knuckle design, a 6-in. outside radius and a straight flange or skirt 6 in. in length were specified. (It will be noted that the minimum inside knuckle radius by the A.S.M.E. unfired pressure-vessel code would be 1.8 in.) Otherwise the heads were designed in accordance with the code, except that a design stress of 9,000 lb. per sq.in.

was used instead of 10,000 lb., as is allowed on plate of the strength specified. The head was dished to a radius equal to the diameter of the shell (5 ft.).

In an attempt to cut down the stresses about the manhole opening, the manhole reinforcing ring was also designed considerably stronger than specified in the code, a 1½-in. saddle plate being used when one 1¼ in. in thickness would have met the code requirements.

The design of the welded joints for all longitudinal and girth seams was of the double-V butt type. The fillet welds joining the manhole reinforcing ring and manhead were so designed that their shearing and tensile strengths were greater than the tensile strength of the material removed from the head. The longitudinal seams are staggered 180 deg.

Used Nickel-Steel Welding Wire

In order to insure the quality of the material used, firebox steel with a maximum carbon content of 0.20 per cent and a minimum tensile strength of 50,000 lb. per sq.in. was specified. The specifications also called for the use of nickel-steel welding wire conforming to the American Welding Society specifications.

The longitudinal seams were staggered 180 deg. Each welder was required to pass a qualification test. The work of welding was carried out strictly in accordance with a procedure worked out from previous experience in jobs of this sort. The finished welds were annealed.

Tested to 1,000 Pounds Twice

On completion of the tank it was first given the regular hydrostatic test. This consisted in applying a pressure of 600 lb. (twice the designed working pressure) and hammering all the welded seams with a 10-lb. sledge. The pressure was then increased to 900 lb. (three times the designed working pressure). This is the limit to which all previously constructed tanks were tested and is the test which is called for on welded vessels in the A.S.M.E. Unfired Pressure-Vessel Code. (It might be pointed out here that since this code allows a design fiber stress of only 5,600 lb. per sq.in., the fiber stress under the required test pressure would be only 16,800 lb. per sq.in. On the ethylene tank the fiber stress at the test pressure was 24,000 lb. per sq.in., or about 50 per cent greater than called for in the code.) Having come to the conclusion, during the construction of this tank, however, that the 8,000 lb. per sq.in. design fiber stress was too low for future construction, the pressure was further increased to 1,000 lb., or the equivalent of three times the working pressure based on a design fiber stress of 9,000 lb. per sq.in.

Final Failure Through Head at 930 Pounds

During these tests strain-gage measurements were taken at various points on the tank. These measurements indicated high stresses around the head knuckles and manhole, particularly about the latter. The tank therefore was again tested to 1,000 lb. pressure to determine if there would be any increase in the permanent set at these points. The second test showed no evidence of distortion except in the metal about the manhole where there was a considerable increase in the permanent set.

The continuous yielding of the metal about the manhole at the 1,000-lb. test pressure indicated a point of danger in the tank, and it was therefore decided to continue the test until no further permanent set occurred at the test pressure, or, if need be, to destruction. At 930 lb. pressure the tank failed through the manhole on the third application of the test pressure.

Fig. 2—Sketch showing meaning of hoop tension and compression, radial tension, etc.
Head shown is of elliptical form with scientifically designed manhole reinforcement.

Welds Not Responsible for Failure

An examination of the head proved conclusively that the welds were in no way responsible for the failure, as they were all intact except as severed cross-sectionally together with the saddle plate and manhead. On the other hand, this failure proved much in favor of the welded joint, the manhead girth weld and the longitudinal weld in the course adjacent to the manhead being in no way affected.

New Head Inserted

In the repair of this tank it was only necessary to remove the defective head and reweld a new manhead, having in it a manhole reinforcing ring of the requisite strength. This was produced from a steel slab having the same chemical and physical properties specified for the shell plate. The slab was first cut by means of an oxyacetylene blowpipe to circular shape and then machined as required to produce the desired fillet and welding bevel. The elliptical manhole was cut out by means of an oxyacetylene blowpipe and the edges of the opening ground smooth.

The rewelding of the manhead girth seam having been completed, the tank was again subjected to the same tests previously indicated. Following the initial test in which the head adjusted itself somewhat to the theoretical elliptical shape, a reapplication of the pressure indicated that the stress in the head and manhole very closely approximated the design fiber stress. The tank was therefore accepted as safe. This was followed by a test for tightness, using 450 lb. air pressure and soapy water. No leaks developed.

In the plant at which the tank under consideration was constructed, the welding of large pressure vessels has become part of the regular production work. Procedure control methods have been thoroughly installed, and this fabricator is now in a sound position to carry on welded pressure vessel work.

The test pressure at which failure occurred was more than 50 per cent greater than could be obtained on a riveted vessel of the same dimensions without starting the rivets and causing leakage at the calking edges. Riveted construction would have made it impossible to reveal the weakness of the head.

Conclusions from Tests

A detailed study was made of the ruptured head, test specimens for tensile and microscopic tests being taken at many points and in many directions. These included samples cut from the body of the weld. The conclusions from these tests were as follows:

1. The weld metal (nickel steel)

shows ample strength and other physical properties.

2. The base metal next the weld was not injured by the heat of welding.

3. There was no significant difference in the physical properties of the metal in different parts of the head.

4. The welds were of good quality, and the fusion and penetration were satisfactory from a production standpoint.

5. There is no evidence that the 1,000-lb. test pressure to which the tank was subjected affected the welds in any way.

A study of the stresses and strains in the head, using the readings of strain gages taken during the hydrostatic tests in connection with an analytical study of strain-stress relations showed the existence of extremely high stresses at the knuckle and the manhole, particularly the latter. They were highest at the edge of the opening but were well above the safety point, even 2 in. away.

Present Head Design Is Irrational

A theoretical study of the design of dished and flanged pressure-vessel heads confirmed the test results and led to the conclusion that present standards of dished-head design are irrational and make the head a weak point in pressure-vessel construction.

The formulas generally used for this purpose are modifications of the basic formula for the strength of a hollow sphere subjected to internal pressure. The formula in the power-boiler section of the A.S.M.E. Boiler Code has been in that code since 1914 and the results of its application seem to have been generally safe, though there have been some head failures.

This formula was devised at a time when boilers were customarily made of thinner plate than at present, and it was probably intended for use in connection with drums rather than for boiler shells. The addition of $\frac{1}{8}$ in. to the formula thickness to take care of a manhole in the head under these conditions was probably well enough, as $\frac{1}{8}$ in. added to a plate of a thickness of about $\frac{1}{2}$ in. would strengthen it considerably; but when the same amount is added to a plate 1 in. or more thick the strength is increased but little.

Short-Radius Knuckles Result in Excessive Stress

The first consideration is the shape of the head. In practice it is usual to design the crown of the head with a radius equal to the diameter of the shell, and to use a knuckle of comparatively short radius. This gives an abrupt change in the radius of curvature of the head at the junction of the knuckle and the crown, and very high bending stresses are set up at this point under conditions of internal pressure. The elastic limit of the material may even be exceeded, and then the head takes on a new shape in which the knuckle merges into the crown gradually, with a steady change in the radius of curvature. If the stress be great enough, the head takes the shape of an ellipsoid. The stress in such a head may be calculated.

In a sphere we have the maximum volume for a given surface, and the sphere would be the ideal theoretical shape for the head of a pressure vessel. Due to practical considerations, however, the depth of the dish of the head should be as low as is consistent with theory.

Theory and experiment show that when the section of the head is an ellipse all bending at the knuckle, or elsewhere, disappears. This, then, is the proper form for a head, the only consideration being the correct ratio of major and minor axis of the ellipse. When the ratio is unity (a semi-circle) the radial and hoop tensions are equal and constant over the entire head and equal to half the maximum fiber stress in the shell.

Whatever the proportions of the ellipse, the two tensions are equal at the center of the head. For a ratio of 1.42 the two start in the center of the crown at three-quarters the shell stress. At the knuckle the hoop tension is zero and the radial tension one-half the shell tension.

When the ellipse ratio is 2, the stress at the center of the crown equals that in the shell and the knuckle is under a compressive stress of equal amount. This ellipse (equivalent to a dishing of one-quarter the shell diameter) is therefore the ideal proportion. Flatter heads increase somewhat the stress at the center and enormously increase the hoop compression in the knuckle.

All this is for a head without a manhole. The introduction of a hole at the center, however small, greatly increases the stresses at that point if the metal is not reinforced. The authors have designed a reinforcement capable of carrying this additional tension. The reinforcement finally used has already been mentioned briefly.

It is the conclusion of all the authors that the customary design of heads dished to a circular arc with knuckles of small radius is wrong and that heads could as easily be made of the proper ellipsoidal shape. They also conclude that the manhole reinforcement is generally insufficient.

Water-Power Development in Canada Making Rapid Progress

THE annual statement of the Water Power Branch of the Canadian government, regarding the development, distribution and use of hydro-electric energy in the Dominion, confirms the estimate made a year ago that during 1926 more than 250,000 hp. would be added to the total hydro-electric development of the Dominion. The actual figure is 266,000 hp., and the total installation now amounts to 4,556,000 hp. During the year projects were actually under way that will ultimately add 1,700,000 hp. to the total development, while three plants in the province of Quebec, comprising a single enterprise, will alone have a capacity double that of the entire new installation during 1926.

The outstanding activities during the year occurred in the province of Quebec, although some of the greatest of these are not reflected in the total of new installations, as they did not reach the production stage. In this province 168,000 hp. was installed, 90,000 of which, in the Isle Maligne Station of the Duke-Price Power Co. on the Saguenay River brings the installation there from 360,000 to 450,000 hp., the ultimate capacity being 540,000 hp. Then, too, there was the replacement of a 1,600-hp. development by one of 22,200 on the Batiscan River by the Shawinigan interests, and a 16,800-hp. addition at the Kipawa plant of the Canadian International Paper Co. The same company is also responsible through its subsidiary, the Gatineau Power Co., for the greatest hydro-electric activity during the year. Two plants on the Gatineau River—one at Chelsea of 170,000 hp. and one at Farmers Rapids of 120,000 hp.—were nearly finished at the end of the year, while a third of 240,000 hp. at Paugan Falls was begun.

Progress was also made on the development of the Aluminum Company of Canada at Chute-a-Caron on the Saguenay River, where 1,000,000 hp. ultimate capacity is in course of construction. The Ontario Paper Co. began the construction of a 40,000-hp. station on the Outarde River.

There was not much actual construction completed in Ontario, but the provincial Hydro Commission has large enterpises in view, which, together with the developments of the Spruce Falls Co. at Smoky Falls on the Mattagami River and the Backus-Brooks Co. on the Seine River, of 70,000 and 37,620 hp. respectively, already begun, will maintain Ontario in its high place among the water-power provinces of the Dominion.

New development in British Columbia amounted to 45,860 hp., of which 25,860 was contributed by the Powell River Co. and 20,000 by the West Kootenay Light & Power Co., which completed its 60,000-hp. plant at Lower Bonnington Falls on the Kootenay River, by the addition of the third unit. This company is carrying on preliminary work in connection with a new 60,000-hp. development at South Slocan. The British Columbia Electric Railway Co. made considerable progress with the construction of the 12,500-hp. Alouette Power Station.

In Manitoba additions to the existing plants of the City of Winnipeg and the Manitoba Power Co. amounted to 43,200 hp., 15,200 of which was represented by the addition of units 15 and 16 to the city's station at Point du Bois on the Winnipeg River. At Great Falls on the same river the Manitoba Power Co. installed unit No. 3 of 28,000 hp. capacity, and let the contract for a similar unit to be installed during 1927.

In the province of New Brunswick the International Paper Co. began work on its Grand Falls development on the St. John's River, which will have an initial installation of 30,000 hp.

News in the Field of Power

Fire at Kips Bay Plant Not Pulverized Coal Explosion As Reported

The New York newspapers for Jan. 2 contained a somewhat misleading account of an accident that occurred at the Kips Bay Station of the New York Steam Corporation, in which one man was seriously burned. The impression created by the newspaper reports was that the accident either resulted in an explosion or was caused by an explosion in the powdered-fuel system in use at the plant. On the contrary, such was not the case.

The boiler house and millhouse sections of the plant are at present in course of construction. At the time of the accident one boiler was in operation, and while two air-separation coal-pulverizing mills and the coal-transport system were available for use, no pulverizing was being done and no coal was being transported. In the operation of the plant, which was being done under considerable difficulty in order to meet the demands for steam, some trouble had been experienced due to condensation in the pipe line between the mill exhauster and cyclone, in the cyclone, and in the discharge line from cyclone to the transport pump. Coal driers had not yet been installed, and as the millhouse was in a most incomplete state, the condensation troubles were caused by the low temperature in the millhouse.

On the day of the accident one of the workmen, while making preparations to start the pulverizing equipment, removed a small handhole cover in the discharge line at the base of the cyclone, presumably to make sure that the cyclone was clear of coal. This permitted a quantity of pulverized coal to run out, and the stream of coal in falling to the floor was ignited by an open salamander that was being used to warm the transport room. The fire created by the falling stream of coal was transmitted to the temporary wooden wall of the transport room, a considerable portion of which was burned away.

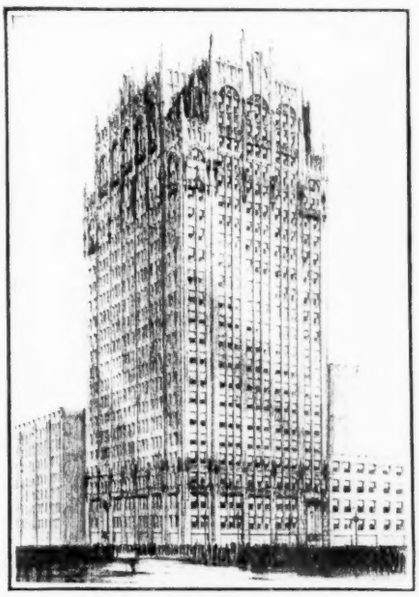
With the exception of burnt windings on two motors that had not yet been installed, practically no damage was done to the equipment.

Would Develop Large Power On Connecticut River

The Northern Connecticut Power Co. has applied to the Federal Power Commission for a permit to build a hydro-electric plant on the Connecticut River, near Hartford. The proposed dam would be 1,150 ft. long, and a total of 50,000 horsepower in six units, operating under 17 to 23 ft. head, would comprise the ultimate installations. Four units would be installed initially.

Chicago to Have Engineering Building

As a New Year's greeting to members, the Western Society of Engineers made the interesting announcement that Chicago is to have an engineering building, and that the Society already has entered into a contract with the promoters of this building, reserving adequate quarters for a minimum of ten years. The new quarters will have



Architect's View of Chicago Engineering Building

nearly double the space now occupied in the Monadnock Block and the use of an auditorium seating 500, which will be on the second floor and will not require the use of elevators to gain access from the street. Thus, with no capital involved except that required for the rental of the space, the Society is soon to realize a dream of years—a home in the new Chicago Engineering Building.

The building is to be financed by Coffey & McKeown, investment bankers, located in the Strauss Building, at an estimated cost of $6,000,000. Zachary T. Davis has been appointed as the architect, and Frank D. Chase, Inc., as the engineers. The location has been chosen on the new Wacker Drive at Wells Street.

The new building will be a beautiful structure, 23 stories high above Wacker Drive, and 2 stories below. Practically one-half of the top floor will be occupied by the Society, and this space will be given over to offices, a lounge, reading room, library and several conference rooms, one of them large enough to accommodate an attendance up to 100. Work on the project will be started about Feb. 1 next, and according to present plans the building should be ready for occupancy during the spring of 1928.

It is believed that members of the engineering profession will find it greatly to their advantage to have offices in the new building, where no doubt other engineering bodies will locate, owing to the advantages offered by the auditorium that will be available, the Society library, and to the concentration of engineering groups in the one building.

Court Rules Utility Commission Cannot Regulate Interstate Rates

A state public utility commission cannot regulate electric rates where the current is transmitted interstate, and the only recourse for a burdensome contract of an interstate character is with Congress, the United States Supreme Court held Jan. 3 in the appeal of the Public Utilities Commission of Rhode Island and the Narragansett Electric Lighting Co. from a decision of the Rhode Island Supreme Court in favor of the Attleboro Steam & Electric Co. Justice Sanford delivered the opinion for the majority, affirming the State court decision, while Justice Brandeis dissented.

In 1917 the Attleboro company, supplying electricity in Attleboro, Mass., and vicinity, contracted with the Narragansett company, operating a plant at Providence, R. I., to supply it with current at the state line and thereafter dismantled its steam plant at Attleboro. After having attempted to have this 20-year contract revised by agreement with the Attleboro company, the Narragansett company filed a new schedule with the Rhode Island Public Utilities Commission, which held a hearing and allowed the new schedule for this contract on the ground the rate was too low and was causing a loss that was unfair to the Rhode Island customers of the Narragansett company. The Attleboro company appealed to the Rhode Island Supreme Court on the ground the State Commission had exceeded its authority and that its order interfered with the commerce clause of the Federal constitution. That court held the order void and the case was appealed to the United States Supreme Court.

Inasmuch as the new schedule of rates would apply to an interstate contract and its effect upon interstate business would not be merely incidental, the Supreme Court held that the Rhode Island Commission cannot increase the contract rate any more than the Massachusetts Commission could reduce it, and that the only chance for relief for the interested parties is in action by Congress.

Contract Let for Birmingham Power Station

A dispatch from London states that acceptance was announced Jan. 5 by the City of Birmingham electricity committee of the £1,548,000 contract for the construction of the first section of the new Hams Hall superpower station, one of the projects under the British Government's electricity scheme. The contract, awarded to the International Combustion Ltd., is said to be the largest single order yet placed in Britain by any electrical undertaking.

Five of the largest water-tube boilers constructed in England are to be installed, having an evaporative capacity of 200,000 lb. an hour. The boilers are to be operated with pulverized fuel. Turbo-alternators, each of 30,000-kw. capacity, house generators of 15,000-kw. capacity, and all the switch-gear transformers, motor generators, as well as condensing equipment, will be supplied by the General Electric Company.

The initial capacity of the first section will be 60,000 kw., but the ultimate capacity will be 210,000 kilowatts.

The contract has been let subject to the approval of the government electricity commissioners, but as all specifications have been prepared by R. A. Chattock of Birmingham, the first municipal engineer in England to adopt pulverized fuel for the successful firing of boilers, its final acceptance is regarded as assured.

The work will include workmen's dwellings, reservoirs, railway sidings and locomotive sheds and will give employment to many men.

St. Lawrence Development Recommended by U. S. Commission

In a report submitted to President Coolidge Jan. 3 by the United States St. Lawrence Commission, Secretary of Commerce Herbert Hoover, chairman, the Commission strongly recommends the development of the St. Lawrence River as a deep waterway in conjunction with the power projects and advises against the All-American route through New York State. The report states in part:

"The reports of the United States engineers of Dec. 6, 1926, estimate the cost of constructing the Lake Ontario-Hudson route at $506,000,000, the All-American route at $631,000,000 (both estimates without interest during construction). No consequential relief by water power can be developed upon these routes. The net cost of the joint governments of the improvement of the St. Lawrence route upon procedure indicated below would be upon the joint engineers' estimates of between $123,000,000 and $148,000,000, from which some further reductions should be made from further realization upon hydro-electric power.

"The development of the St. Lawrence waterway is necessarily also a development of the huge hydro-electric power from the great rapids which now obstruct navigation on the river. The complete practical power development of the river will provide a total of about 5,000,000 installed horsepower, of which about 2,250,000 lies in the upper rapids along the international section between New York State and the Province of Ontario, the remainder lying in the lower rapids and wholly within the Dominion of Canada.

"This is not only the largest possible hydro-electric power development upon the continent, but the reports of the engineers indicate that the capital outlay per horsepower is less than most of the hydro-electric installations now in progress in the United States. The inevitable development of the river for power would in itself compass the major construction for the shipway, since the dams necessary for development of power create a series of pools in place of the present rapids which, with the supplement of locks and short canals, become the shipway. The development of these vast power resources is inevitable in the interest of the populations in that region. Their development will eventually create a shipway on this route even if other routes were undertaken."

Resigns the Presidency of McGraw-Hill Book Co.

Edward Caldwell has resigned from the presidency of the McGraw-Hill Book Co., Inc., 370 Seventh Avenue, New York City and will retire from active business.

Mr. Caldwell has been associated with the McGraw-Hill interests for 36 years, having been one of the organizers of the McGraw-Hill Book Co., Inc., in 1909. He has been active in its management since its formation. He will, however, remain on the boards of directors of the McGraw-Hill Book Co., Inc., and the McGraw-Hill Publishing Co., Inc.

Martin M. Foss, who was associated with Mr. Caldwell in the organization of the McGraw-Hill Book Co., Inc., has been chosen to succeed Mr. Caldwell as president.

April 18 to 23 To Be Oil Power Week

The Oil Power National Conference Steering Committee has designated the week of April 18 to 23 as Oil Power Week and has already arranged for fifty meetings. It is probable that this number will be augmented. Among the subjects to be discussed at these meetings will be "Injection Nozzles and Fuel Pumps for High-Speed Oil Engines," "Engine Developments for Aircraft," "Operating Experiences with Various Fuels," and "The Oil Engine as a Decentralizer in Industry."

The committee has designated the annual prize for the best paper under its program as the "Rudolph Diesel Award." This consists of $100 cash and an engrossed certificate. Previous to the conference at which it is read, the paper must not have been read or published in any form. It will be recalled that the 1926 prize was presented to Fred Thilenius, master mechanic of the Prairie Pipe Line Co. at the recent A.S.M.E. Annual Meeting.

Small Prospects of Congress Passing Coal Legislation

President Coolidge has on two different occasions suggested to Congress the appointment of a fact-finding commission as a means of helping the coal industry. The report of the United States Coal Commission made in 1923 also contained such recommendations. Secretary Hoover has recommended that the industry be given a period in which it could set up by voluntary means, the machinery for fact finding and for the adjustment of labor disputes. These things have not been done, and this question will probably be brought before the present Congress.

On Jan. 11 the Committee of Interstate and Foreign Commerce of the House of Representatives will consider the Parker coal bill. The provisions of this bill fall under three separate heads: Fact finding; mediation, conciliation and arbitration, and emergency distribution. Each of these depends upon a different branch of the federal government for administration.

The fact-finding section of the bill is to be administered by the Secretary of Commerce through the Bureau of Mines. Facts are to be gathered, analyzed, compiled and made public to protect against coal shortages, for the enactment of further emergency legislation, and to determine a sound public policy regarding the industry.

According to the mediation and conciliation provisions of the bill, the President may direct the Secretary of Labor to conciliate differences, encourage arbitration or act as mediator; appoint one or more persons to act as mediators; and establish temporary boards of mediation. Such agencies may have access to all information in any government department.

The administration of the emergency distribution section of the bill is a divided responsibility between the Interstate Commerce Commission and the Federal Fuel Distributor. Upon the date of a declaration by the President of the existence of an emergency, the provisions of Sections 2, 3, 4, 5 and 7 of the Act of 1922 creating a Federal Fuel Distributor are revived. These sections empower the Interstate Commerce Commission to provide by priority order, embargo or otherwise, preferential movement of coal; equitable distribution of coal in the public interest; and prevent the purchase or sale of coal at prices unjustly or unreasonably high.

Speculation by persons outside of the committee on the chances of the passage of the bill, if it should be reported favorably, is that it will have little chance for passage at this session. Less progress seems to have been made on the Copeland bill in the Senate. The upper House already has a full program and is facing time-consuming controversies over political questions. Half of the session will have gone by before the Parker bill can get out of committee, and it seems hardly likely that legislation of this sort will be able in the short time remaining to run the gauntlet of action in the House, in the Senate, and in the Conference Committe and finally to secure approval of the conference reports.

Combats Fake Correspondence Schools

The American Association of Engineers is reported to have drafted a bill, for presentation to various state legislatures, that would do away with the dishonest practices of certain so-called correspondence schools offering engineering courses. Through its local chapters the Association has conducted an investigation into the practices of many of these schools and reports that of all the courses in advertising studied 60 per cent could be classed as fraudulent.

Obituary

Henry N. Winner, for the last four years general manager of the Garlock Packing Co., Palmyra, N. Y., died at Philadelphia on Nov. 12, 1926, after a brief illness. He was born in Brooklyn Sept. 19, 1879 and spent his entire life in the mechanical packing business. Mr. Winner was a member of the Machinery Club of New York City, the Oak Hill Country Club of Rochester, and the Rochester Consistory and Damascus Temple.

Frank R. White, of the Fisher Governor Co., of Marshalltown, Iowa, died on Sunday morning, Dec. 26, as the result of an operation performed on the previous Thursday. Mr. White had been with the company for eight years, starting in the cost accounting department and gradually advancing to the position held at his death. He was born in Stark County, Ill., on Feb. 20, 1884, and came to Marshall County, Iowa, in 1896. Since 1911, he has resided in Marshalltown and through his services with the Fisher Governor Company had become favorably known in the engineering field. He is survived by his widow and two sons.

Personal Mention

Arthur J. Whitcomb, associate editor of *Industrial Engineer* for the last three years, is now with the Freyn Engineering Co., Chicago, Ill., in the capacity of assistant electrical engineer.

Dr. M. L. Hartmann has resigned as director of research of the Carborundum Co., Niagara Falls, New York, to become technical director of the Celite Products Co., whose research laboratory is at Lompoc, Calif.

R. H. Carter has joined Elliott Company's Detroit district office. Mr. Carter is an old experienced construction and operating engineer, both marine and stationary. Recently, he constructed and put in operation the new turbine station of the Illinois Steel Co. at Gary, Ind.

James A. Davies has been appointed general superintendent of the South Philadelphia Works, Westinghouse Electric & Manufacturing Co., to fill the position made vacant by the recent death of H. M. Giles. Mr. Davies has been assistant general superintendent for the last eight years.

Dr. Ira M. Hollis, former head of the Worcester Polytechnic Institute and past-president of the American Society of Mechanical Engineers, is making an extensive tour through the South visiting local sections of the A.S.M.E. The general subject of his talks is "The Engineer in the South."

Coming Conventions

American Engineering Council. Annual meeting at Washington, D. C., Jan. 13-15. L. W. Wallace, 24 Jackson Place, Washington, D. C.

American Institute of Electrical Engineers. Winter convention at New York City, Feb. 7-10; F. L. Hutchinson, secretary, 33 West 39th St., New York City.

American Society of Heating and Ventilating Engineers. Annual meeting at St. Louis, Mo., Jan. 25-28; A. V. Hutchinson, secretary, 29 West 39th St., New York City.

Chicago Power Show, at Chicago, Feb. 15-19. G. E. Pfisterer, managing director, 53 West Jackson Blvd., Chicago.

Engineering Institute of Canada. Richard John Durley, secretary, 176 Mansfield St., Montreal, Que. The forty-first annual general and general professional meeting will be held at Montreal on Thursday, Jan. 27, and will be adjourned to reconvene at Quebec City at the Chateau Frontenac Hotel Feb. 15, continuing on the two succeeding days.

Midwest Power Conference, at Chicago, Feb. 15-18. Sessions will be held in the Coliseum concurrently with the Chicago Power Show; G. E. Pfisterer, secretary.

National Association of Stationary Engineers—Annual convention at Los Angeles, Aug. 22-27.

National Association of Stationary Engineers. New England States convention at Portland, Me., June 17-18. Thomas H. Clark, president, Worcester, Mass.; Robert Johnson, secretary, 65 Charlotte St., Worcester, Mass.

National Electric Light Association. A. Jackson Marshall, secretary, 29 West 39th St., New York City. Annual convention at Atlantic City, week beginning June 6.

National Marine Engineers' Beneficial Association. Fifty-second annual convention at the Hotel Franklin Square, Washington, D. C., Feb. 14. Albert L. Jones, secretary-treasurer.

Business Notes

The Banks-Miller Supply Co., of Huntington, W. Va., has recently been appointed as district representative for territory covering the vicinity of Huntington for the Foote Bros. Gear & Machine Co.

The Foote Bros. Gear & Machine Co. announces the recent appointment of the Progressive Machine & Engineering Corp., 1335 E. Franklin St., Richmond, Va., as district representatives covering the State of Virginia.

Trade Catalogs

Steam Superheaters — The Power Plant Equipment Co., Kansas City, Mo., has issued a trade catalog on the Marley steam superheater for horizontal return tubular boilers.

Centrifugal Air Compressors — The General Electric Co., in an illustrated folder GEA-528, depicts with short description centrifugal air compressors of the small, multi-stage variety. Construction details are given by means of an exposed cross-section.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run except Pittsburgh gas slack:

Bituminous Net Tons	Market Quoting	Jan. 3 1927
Pool 1	New York	$3.50@$3.75
Smokeless	Boston	2.32½
Clearfield	Boston	1.95@ 2.70
Somerset	Boston	2.10@ 2.80
Kanawha	Columbus	1.75@ 2.00
Hocking	Columbus	1.75@ 2.00
Pittsburgh	Pittsburgh	2.00@ 2.25
Pittsburgh gas slack	Pittsburgh	1.60@ 1.70
Franklin, Ill.	Chicago	2.50@ 2.75
Central, Ill.	Chicago	2.00@ 2.25
Ind. 4th Vein	Chicago	2.25@ 2.50
West Ky.	Louisville	1.35@ 1.75
S. E. Ky.	Louisville	1.75@ 2.00
Big Seam	Birmingham	1.75@ 2.00
Anthracite Gross Tons		
Buckwheat No. 1	New York	2.50@ 3.50
Buckwheat No. 1	Philadelphia	2.50@ 3.00
Birdseye	New York	1.35@ 2.00

FUEL OIL

New York—Jan. 5, light oil, tank-car lots; 28@34 deg. Baumé, 5¾c. per gal.; 36@40 deg., 6¼c. per gal. f.o.b. Bayonne, N. J.

St. Louis—Dec. 28, tank-car lots, f.o.b. St. Louis; 24@26 deg., $2.05 per bbl.; 26@28 deg., $2.10 per bbl.; 28@30 deg., $2.15 per bbl.; 30@32 deg., $2.20 per bbl.; 32@36 deg., gas oil, 6.3c. per gal.; 38@40 deg., 7.37c. per gal.

Pittsburgh—Jan. 1, f.o.b. local refinery; 30@34 deg., fuel oil, 6¼c. per gal.; 36@40 deg., fuel oil, 6¾c. per gal.

Philadelphia—Dec. 31, 27@30 deg., $2.52@$2.58 per bbl.; 13@19 deg., $1.725@$1.785 per bbl.

Cincinnati — Jan. 4, tank-car lots f.o.b. local refinery, 24@26 deg. Baumé, 6½c. per gal.; 26@30 deg., 6⅝c. per gal.; 30@32 deg., 7c. per gal.

Chicago—Jan. 3, tank-car lots f.o.b. Oklahoma, freight to Chicago, 92c. per bbl.; 24@26 deg., $1.35 per bbl.; 26@30 deg., $1.40; 30@32 deg., $1.65.

Boston—Jan. 3, tank-car lots f.o.b. 12@14 deg. Baumé, 4.65c. per gal.; 28@32 deg., 5.9c. per gal.

Dallas—Jan. 1, f.o.b. local refinery, 26@30 deg., $1.80 per bbl.

New Plant Construction

Ark., Gould—Gould Cooperage, Light & Ice Co., D. V. Leatherma, Pres., will build an electric light and ice plant, 20 ton capacity by day labor. Estimated cost $50,000. Owner is in the market for steel cooling tower.

Ark., Prescott—Southern Ice & Utilities Co., Sante Fe Bldg., Dallas, Tex., plans the construction of an ice plant here. Estimated cost $200,000. Private plans.

Calif., Bakersfield—Kern County Labor Council, plans the construction of an ice and cold storage plant. Estimated cost $150,000.

Calif., Martinez—Union Ice Co., 354 Pine St., San Francisco, will build a 1 story addition to ice plant at Escobar and Pine Sts. here by day labor. Estimated cost $4,500.

Calif., San Luis Obispo—San Luis Ice & Cold Storage Corp., awarded contract for the construction of a cold storage plant to Hamm, Grant & Bruner, 607 Ferguson Bldg., Los Angeles. Estimated cost $55,000.

Conn., East Hampton—Central Connecticut Power & Light Co., 72 Main St., plans the construction of a power plant and dam, 80 ft. high on the Salmon River at Leesville. Total estimated cost $1,025,000.

Ill., Olney—City will receive bids until Jan. 18 for the construction of a waterworks system including 2 dams, 1,500,000 gal. filtration plant, two 750 g.p.m. dual drive centrifugal pumps, two 500 and one 3,000 g.p.m. motor driven pumps, 150,000 gal. tank on tower, etc. Estimated cost $168,000. Edward Flad & Co., Chemical Bldg., St. Louis, Mo., are engineers.

Ky., Louisville — Graham, Anderson, Probst & White, 80 East Jackson Blvd., Chicago, Ill., Archts., will receive bids until Jan. 12 for the construction of a 17 story office and stores building including boiler room, water cooling plant, etc. at 4th St. and Broadway here for Heyburn Building Co. Estimated cost $2,000,000.

Mass., Boston — Quincy Market Cold Storage & Warehouse Co., 178 Atlantic Ave., will build a power house at 69 Eastern Ave. by day labor. Estimated cost $75,000. F. L. Fairbanks, 133 Commercial St., is engineer.

Mo., Springfield—Springfield Ice & Refrigeration Co., A. J. Johnson, 227 West Mill St., awarded contract for the construction of a cold storage plant to W. E. Fogerson, 919 South McCann St. Estimated cost $130,000.

N. Y., Long Island City—Rubel Coal & Ice Co., 197 Glenmore Ave., Brooklyn, is having plans prepared for the construction of an ice plant here. Estimated cost $150,000.

N. Y., New York—Empire State Ice Co., Grant Ave. and 161st St., awarded contract for the construction of an ice manufacturing plant to Niewenhous Co. Inc., 16 East 43rd St. Estimated cost $350,000.

N. D., Devils Lake—City plans an election Jan. 12 to vote $55,000 bonds for waterworks improvements including new well, pump house, etc.

Okla., Ponca City—City voted $300,000 bonds for the construction of a new electric light plant including two 1250 hp. Diesel engines. J. W. Crow, is engineer.

Okla., Seminole — Western Ice & Cold Storage Co., c/o Oklahoma Utilities, Local Bldg., Oklahoma City, awarded contract for the construction of a 20 ton ice and cold storage plant to Pillsbury-Becker Co., Dallas, Tex. Estimated cost $45,000.

Tex., Alpine—Central Power Co., Grand Island, Neb., is having surveys made for improvements to power plant including new engine unit, etc. here. Estimated cost $30,000. Private plans.

Tex., Quanah—Southwestern Light & Power Co., 72 West Adams St., Chicago, Ill., has acquired a site and plans the construction of a power plant at Lake Pauline here. Estimated cost $250,000. L. C. Miller, c/o owner, is engineer.

Wis., Antigo—Kraft Cheese Co., 402 Rush St., Chicago, Ill., awarded contract for the construction of addition to power house here to A. Marmes. Estimated cost $50,000.

Ont., Drayton—Village, A. C. Woodman, Clk, plans the construction of a waterworks system including 3 wells, pumps, mains, etc. Estimated cost $35,000. Engineer not selected.

POWER

Information Bureau

Your machinery, equipment, and materials requirements will be advertised *free of charge* in the New Plant Construction section of Power. This will place you in direct contact with the manufacturers and dealers who can supply your needs most attractively—both as to cost and as to prompt delivery. The coupon is for your convenience—

A. W. WELCH
Power Equipment Bureau
Tenth Ave. at 36th St., New York, N. Y.

In the market for.....

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Name .....

Company or Plant.....

Address .....

Power Equipment

Calif., Colusa—Union Ice Co., 354 Pine St., San Francisco, is in the market for equipment for ice plant here. Estimated cost $40,000.

Calif., Mare Island—Bureau of Yards & Docks, Navy Dept., will receive bids until Feb. 9, for heating plant equipment and piping.

Mo., St. Louis—J. B. Hartman, 4317 Forest Park Blvd., plans to purchase a 40 to 100 hp. gas engine, also air compressor.

N. J., Jersey City—J. E. Lytle, 301 Princton Ave., wants prices or catalogs for variable speed reducers, Lelewar preferred.

O., Cleveland—V. La Salle, 7809 Harvard Ave., is in the market for waste heat boilers, coal pulverizers and Diesel engines.

O., Columbus—Dept. of Welfare, J. E. Harper, Dir., Ninth and Oak Sts., will receive bids until Jan. 27 for two steam driven air compressors, and two motor driven pumps for Institution for Feeble Minded, also two 100 hp. and two 250 hp. water tube boilers, coal and ash handling equipment, etc. for Ohio School for the Deaf.

Okla., Ponca City—City, C. E. Norton, Clk., is in the market for 2 new 1,250 hp. Diesel engines for electric light plant.

Pa., Warren—Bd. of Trustees, H. W. Mitchell, Supt., will receive bids until Jan. 20, for furnishing and installing three engines and generators, switchboard, etc. J. E. Woodwell, 501 5th Ave., New York, N. Y., is consulting engineer.

Wis., Milwaukee—Dept. of Public Works, R. Stoelting, Comr., will receive bids until Jan. 18 for three 400 hp. horizontal water tube boilers with furnaces, mechanical stokers, superheaters, forced draft apparatus, etc. for Riverside pumping station, J. Schwada, City Hall, is engineer.

Wis., Randolph—B. C. Kelley, wants prices or catalogs for two 200 hp. boilers and one 150 kw., 125-250 d.c. generator direct connected to reciprocating engine.

N. Z., Wellington—New Zealand Government Railways, will receive bids until Apr. 18, for electric overhead traveling cranes, 4-100 ton 78 ft. 6 in. span, 2-25 ton 80 ft. span, 16-10 ton 47 ft. span, 3-10 ton 67 ft. 6 in. span, 4-10 ton 75 ft. span, 6-7½ ton 47 ft. span, 1-7½ ton 80 ft. span, 9-5 ton 47 ft. span, 1-5 ton 50 ft. span, 2-5 ton 78 ft. 8 in. span, 4-2 ton 39 ft. 3 in. span, 3-2 ton 47 ft. span; 3 electric traversers, 120 jib cranes, 20 electric capstans, 4 electric mobile cranes, etc.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

LEAD covered and other armored cable registered substantial price advances during the last month. Recent rise in quotations on rivets affected structural rather than cone-head boiler style. Declines were confined to minor items on the list, such as, the drop of 5¼c. per 7½-lb. gal. in linseed oil and recessions ranging from ½c. to 4c. per lb. in various grades of babbitt metal at New York.

POWER-PLANT SUPPLIES

HOSE—Quotations at New York warehouses:

	Fire Protection	50-Ft. Lengths
Underwriters' 2½-in., coupled, sing'le jacket	(net)	68c. per ft.
Common, 2½-in., cotton-rubber lined	80c. per ft. list less	50%

Air—Best grade

¾-in., per ft.	3-ply	$0.34	4 ply	$0.42

Steam—Discounts from List

First grade	40%	Second grade	40–5%	Third grade 50%

RUBBER BELTING—List price 6-in., 6 ply, $1.83 per lin.ft. The following discounts from list apply to rubber transmission belting:

Best grade	50%	Second grade	50–10%

LEATHER BELTING—List price, 24c. per lin.ft. per inch of width for single ply at New York warehouses.

Grade	Discount from list
Medium	40–5%
Heavy	30–10%

RAWHIDE LACING { For cut, best grade, 50%, 2nd grade, 60%. For laces in sides, best, 41c. per sq.ft.; 2nd, 37c. Semi-tanned: cut, 50%; sides, 41c. per sq.ft.

PACKING—Prices per pound at New York warehouses:

Rubber and duck for low-pressure steam, ⅛ in.	$1.05
Asbestos for high-pressure steam, ⅛ in.	1.85
Duck and rubber for piston packing	1.05
Flax, regular	1.15
Flax, waterproofed	1.70
Compressed asbestos sheet	.95
Wire insertion asbestos sheet	1.40
Rubber sheet	.60
Rubber sheet, wire insertion	.85
Rubber sheet, duck insertion	.65
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.40
Asbestos wick, ½- and 1-lb. balls	.50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		50%
Asbestos, air cell, for low-pressure heating and return lines	4-ply	70%
	3-ply	72%
	2-ply	74%

PORTLAND CEMENT—New York, $2.50@$2.60 per bbl. without bags, in carload lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.34 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York	Cleveland	Chicago
White	13.00@17.50	18.00	15.00@20.00
Colored	10.00@14.00	13.50	12.00@17.00

WIPING CLOTHS—Prices per pound in lots of about 600 lb., for washed, white wipers, as follows:

Chicago	$0.15
New York	.17½
Cleveland (*per thousand*)	36.00

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.81	$0.98	$0.83

WHITE AND RED LEAD—Per 100-lb. keg, base price, f.o.b. New York:

	Dry		In Oil	
	Current	1 Yr. Ago	Current	1 Yr. Ago
Red	$15.25	$15.25	$16.75	$16.75
White	15.25	15.25	15.25	15.25

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

Rivets, 7/16x1-in. and longer, 10c. per lb., less 50% at New York warehouses Same discount for tinned. EXTRA per 100 lb. for 1½ to 2-in. long, all diameters, 25c.; ⅝-in. dia., 35c.; ¾-in., dia., 75c.; 1-in. long and shorter, 75c.; longer than 5-in., 50c.; less than 200 lb., 50c.; countersunk heads, 45c.

Structural rivets, per 100 lb.:

New York	$4.20	Chicago	$3.50	Pittsburgh	$2.60

Cone-head boiler rivets, per 100 lb.:

New York	$4.40	Chicago	$3.70	Pittsburgh	$2.90

REFRACTORIES—Prices in car lots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$45.00
Chrome cement, 40@50% Cr_2O_3, in bulk	net ton	22@25
Chrome cement, 40@50% Cr_2O_3, in sacks	net ton	26@29
Magnesite brick: 9-in. straights	net ton	65.00
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50
Magnesite brick: Soaps and splits	per ton	91.00
Silica brick: Mt. Union, Pa.	per M	43.00
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	40@45
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	40@43
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	40@43
Clay brick, 1st quality, 9 in. shapes, Maryland	per M	43@46
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per M	33@38
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	38@40
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	38@40
Clay brick, 2nd quality, 9 in. shapes, Maryland	per M	38@40
Chrome ore crude, 40@50%	net ton	18.00@22.50

BABBITT METAL—Delivered, New York, cents per lb.:

Genuine, highest grade	86.00
Commercial genuine, intermediate grade	61.50
Anti-friction metal, general service	32.50
No. 4 babbitt (f.o.b.)	13.50

COLD DRAWN STEEL—Warehouse prices are as follows:

	New York	Cleveland	Chicago
Round shafting and screw stock, per 100 lb. base	$4.00	$3.90	$3.60
Flats and squares, per 100 lb. base	4.50	4.40	4.10

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	65-5%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots at Pittsburgh mill:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	62	50½	1 to 1½	30	12

LAP WELD

2	55	43½	2	23	7
2½ to 6	59	47½	2½	26	11
7 and 8	56	43½	3 to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	1 to 1½	30	14
2 and 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	2
11 and 12	44	31½			

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$17 07
1¼	.....	.....	19 20
1½	.....	$38 00	17 92
1¾	.....	28 50	20 48
2	$17 33	25 00	20 24
2¼	19 84	28 25	23 00
2½	21 60	34 00	26 03
3	25 50	42 50	27 01
3¼	30 25	49 50	30 67
3½	31 50	52 75	33 33
4	38 03	67 00	40.11

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per 100 ft. based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

2 in. and smaller, 5c. per cut. 3 in., 9c. per cut
2¼ and 2½ in., 6c. per cut. 3½ to 4 in., 10c. per cut

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$32.00 (net)	$ 51 00 (net)	$180.00	$220.00
No. 12 solid	186.00	180 00	225.00	275 00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	205.00	305.00	420 00	500.00
No. 6 stranded	440.00	530.00	615 00	.....

From the above lists discounts are:		Lead Covered
Less than coil lots	50%	20%
Coils to 1,000 ft.	60%	30%
1,000 to 5,000 ft.	60–5%	35%
5,000 ft. and over	60–10%	38%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f.o.b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
⅜	$56.50	$61.34	$7 76	$8.83	$4.52	$4.92
½	72.07	78.63	10.21	11.63	6.46	7.03
¾	103.31	113.00	15 10	17.21	8.39	9 13
1	139.77	152.88	20.51	23 07	11.78	12.75
1¼	167 12	182.79	27.34	30.76	14.56	15.75
1½	224 85	245 94	50 13	56 40	19.41	21 01
2	355 50	388.85	82 03	92 28	27.73	30 01
2½	464 88	508 50	218.74	246 10	41.59	45.01
3	585 30	637.74	483 04	543 46	55.46	60 02
3½	714 17	776.30	558.23	628 06	69.32	75 02
4						

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG, SOLID NEUTRAL OR 2 FUSE

S. P. M. L.	$0.12	D. P. D. B.	$0.31
D. P. M. L.	.16	T. P. S. B.	.35
T. P. M. L.	.27	T. P. D. B.	.47
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE, SOLID NEUTRAL OR 2 FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.27	$0.70	$1.75
T. P. M. L.	.40	1.00	2.30
D. P. S. B.	.35	.87	.....
T. P. S. B.	.67	1.50	.....
D. P. D. B.	.65	1.75	.....
T. P. D. B.	1.12	3.00	.....
T. P. to D. P. D. B.	.75	2.10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy		$18.50
No. 16 cotton reinforced heavy		23.50
No. 18 cotton reinforced light		16.00
No. 16 cotton reinforced light		20.50
No. 18 cotton Canvasite cord		15.50
No. 16 cotton Canvasite cord		19.00
No. 16 super service cord or similar (2 wire) in 1,000 ft.	$92.00	*101.20
No. 14 super service cord or similar (2 wire) in 1,000 ft.	133.00	*146.40

*Less than 1,000 ft.

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30 amp.	100	$0.15	3-amp. to 30-amp.	100	$0.30
35-amp. to 60 amp.	100	.30	35-amp. to 60-amp.	100	.60
61-amp. to 100 amp.	50	.90	65-amp. to 100-amp.	50	1.50
101-amp. to 200-amp.	25	2.00	110-amp. to 200-amp.	25	2.50
201-amp. to 400-amp.	25	3.60	225-amp. to 400-amp.	25	5.50
401-amp. to 600-amp.	10	5.50	450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package, 60%; 1-5th to standard package, 64%; standard package, 68%.

RENEWABLE FUSES—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4 00	5.00	25	5
225 to 400-amp.	7.50	11 00	25	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30-amp.	$0.03 ea.	$0.05	100	100
35 to 60-amp.	.05 ea.	.06	100	100
65 to 100-amp.	.10 ea.	.10	50	50
110 to 200-amp.	.15 ea.	.15	25	50
225 to 400-amp.	.30 ea.	.30	25	25
450 to 600-amp.	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package (500)	$2.75
0-30 ampere, less than standard package	3.00

LAMPS—Below are present quotations in less than standard package quantities on Mazda standard A type bulbs:

100—130 Volt Watts	Type	Price Each	200—260 Volt Watts	Type	Price Each
				Special	
15	A 17	$0.25	25	A 19	$0.30
	General		50	A 21	.30
25	A 19	.25	100	A 23	.53
40	A 21	.25			
50	A 21	.27			
60	A 21	.30			
100	A 23	.43			

Standard pkg. quantities are subject to discount of 10% from list. Annual contracts ranging from $75 to $300,000 net allow a discount of 15 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.18
Composition 2-piece attachment plug	.27
Swivel attachment plug	.12
Small size—2 Pc. Plug—Composition	.07

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$6 60	$9.75	$11 60	$18.20
12	10 10	12 60	14 60	23.80
10	13 20	16 40	18 60	30 50
8	19.00	22.30	24 20	42.40
6	.....	.....	34 40	.....
4	.....	.....	48 00	.....
2	.....	.....	68 75	.....
1	.....	.....	94 70	.....
0	.....	.....	115 00	.....
00	.....	.....	138 00	.....
000	.....	.....	165 00	.....
0000	.....	.....	196 00	.....

SOCKETS, BRASS SHELL—Price each, net:

	½ In. or Pendant Cap Key	½ In. or Pendant Cap Keyless	½ In. or Pendant Cap Pull	¾ In. Cap Key	¾ In. Cap Keyless	¾ In. Cap Pull
Standard package	$0.17	$0.15	$0.22	$0.20	$0.18	$0.25
Unbroken carton	.18	.16	.23	.22	.19	.26
Broken carton	.20	.18	.25	.24	.21	.28

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 35c. lb., 100 lb. lots	33c. lb.
Rubber tape, ¾ in., less 100 lb. 37c. lb., 100 lb. lots	35c. lb.
Wire solder, less 100 lb. 29c. lb., 100 lb. lots	31c. lb.
Soldering paste, 2 oz. cans	$1.00 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c or a.c., N.E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	30%
$25.00 to $50 0 list value	30–5%
$50.00 list value or over	35%